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An Illustrated Weekly Journal

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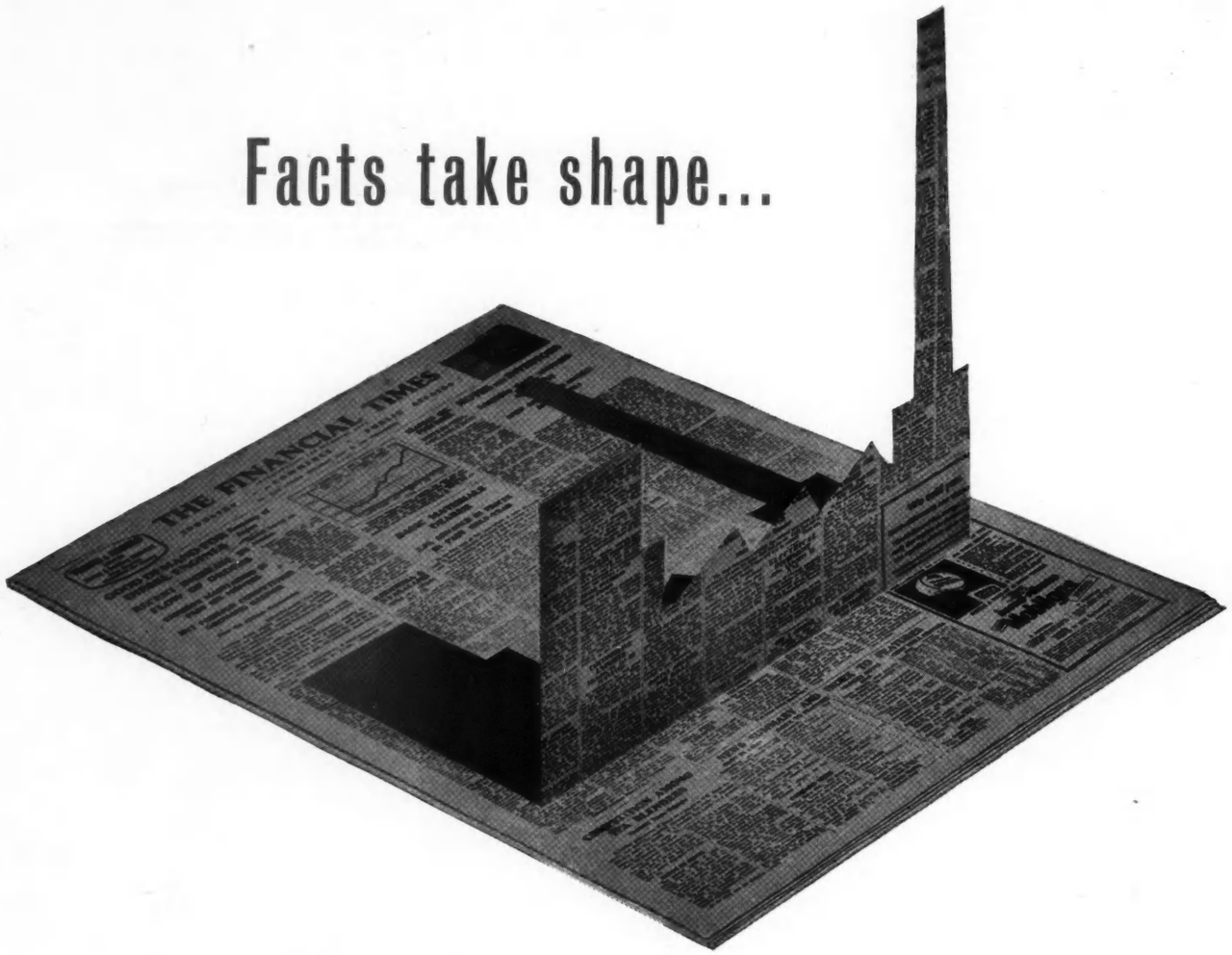

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ACCIDENT OF BIRTH

SOME metals, like some children, are born with silver spoons in their mouths (if that is not stretching the metaphor too far). Take nickel, for example. Nature decreed in prehistoric times that the principal deposits of its ore should be located in a small area of Ontario, Canada. As a result of that accident of birth, nickel has been fathered in the Twentieth Century by one great organisation—the International Nickel Company of Canada ("Inco")—which can, and does, employ all possible techniques of research, selling and publicity to extend its uses. The Chairman of Inco, Dr. J. F. Thompson, now on a visit to Europe, said in London this week that the possible uses of nickel were limited only by the imagination and drive which the Company's staff put into its exploitation. The resources of business, metallurgy and engineering join in a combined operation.

Nature's capriciousness can retard as well as promote the uses of a material. If stone in this country, for instance, were concentrated almost entirely in one vast quarry, and if that quarry were controlled by one large business undertaking, the probability is that the use of stone for building and other purposes would be extended far beyond its present restricted uses. And it would be done by intensive development of the techniques of quarrying, handling, etc., allied to a continuous drive to market the product.

This is not an argument for monopoly. It serves to show that the potential value of a material—or, indeed, any technique or invention—can easily remain unexploited if the control of it is in the hands of innumerable organisations each one of which is without adequate resources of money, manpower and brains to exploit it. The quality of housing has suffered from this very circumstance: no one can deny that the average quality has not risen nearly as much as it should have done in relation to the advances made during the past hundred years in constructional materials, design knowledge, and engineering techniques in general. Increases in spending power have been largely absorbed by luxuries; housing, one of the few basic needs of life, has been relegated to a low priority, in quality if not in quantity.

The first and most familiar use of nickel—to give a durable undercoating to chromium plating—is even now second only in importance to its use in alloy steels. Restrictions on the distribution and end-uses of the metal which were in operation until the latter part of 1953 caused the plating industry to seek alternative finishes, and must, indirectly, have led some users to look for materials that required no finishing plate before service. The end of restrictions by the governments of the United States, Canada and Great Britain has not resulted in ample supplies for all users. According to Dr. Thompson there is still a shortage of the metal, in spite of increasing production. Last year about 66 per cent. of the "free world's" supply was taken by the United States and a total of about 17 per cent. went to Canada and the United Kingdom. The United States requires a high proportion of its allocation for defence production and for stockpiling. The American Government attach such importance to stockpiling that they pay a bonus, over and above the normal price, to make it economical for Inco to work the lower-grade ores.

The renewal of military requirements for the metal during rearmament had an influence, also, on the use of alloy steels. The nickel content was reduced, and it has not since been completely restored, but meanwhile some of the lower nickel-containing steels have been found to be suitable for purposes to which the higher-content steels were not economically suited. The lesson which has been learned here is evidently that a change in market conditions which, on the face of it, is detrimental, can be turned to good account.

As someone remarked recently, engineers are spoilt for choice. There are now so many materials at their disposal, many of them not metals, that the task of selecting the most suitable is formidable. It is not a task to be side-tracked because of its complexity. Undertaken with intelligence and forethought, it can have a profound effect on design, production, and ultimately the market for the product in question. Most materials are the concern of a particular firm or firms, or of a development association, so the engineer is relieved of much of the patient inquiry which would otherwise be necessary. He can approach several appropriate organisations and put his problem to them in the sure knowledge that they will not be slow to suggest suitable materials from which he can make a final selection. These facilities present a further interesting possibility: namely, that instead of looking for a suitable material after the general arrangement of the design has been settled, the engineer can start by reviewing the possibilities of all likely materials, and only then let the design begin to take shape. If this approach is allied to an open mind on production methods, the probability is that the optimum design will emerge. Progress is not only by "back-room" work, however original, but by the interchange of ideas, the selling and buying of service and material, which takes place continually between those who are prepared to give as well as take.

Weekly Survey

R.E.M.E. WORK IN THE FUTURE

Speaking at the seventh annual R.E.M.E. Officers' Dinner in London last week, General Sir Ouvry L. Roberts, Quarter-Master General to the Forces, said that he expected the Corps of Royal Electrical and Mechanical Engineers to be responsible, in the not far distant future, for maintaining the Army's helicopters, guided missiles and a greatly increased range of electronic equipment.

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FIXED-PRICE CONTRACTS

In common with other authorities the London County Council has, since the war, used a standard form of contract for major works which has contained a fluctuation clause in respect of both wages and prices of materials. It has, however, been considered a matter of principle that there should be a return to fixed-priced tendering as soon as circumstances permitted. So far as wages are concerned, the General Purposes committee of the Council recognise that stability has not yet been reached, but the committee is of the opinion that the prices of building and civil-engineering materials have been as stable over the last two years as they were before the war.

It is therefore the intention to introduce a simple system of alternative tendering. For contracts where orthodox materials and methods are to be employed and the contract period is not to exceed two years, contractors are to be invited to tender on two bases: as at present, with the fluctuations clause applying to both wages and materials; and with the clause applicable to wages only, that is to say, with fixed prices for materials. Contractors will be free to tender on either or both bases.

The fluctuation clause for materials as well as for wages is to be retained for contracts where the contract period will exceed two years or where unusual methods of construction are to be adopted and special considerations are likely to arise.

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DECISION ON THE CENSUSES

Last week the Government accepted the recommendations of Sir W. R. Verdon Smith's Committee on the Production and Distribution Censuses. The committee came to the conclusion that these censuses were necessary. An effort has been made, however, to reduce the burden of form-filling on industry. The last full Census of Production was taken for 1951, and the details have not yet been completely published. The next full census will be taken in 1955 for 1954. There have been in addition sample surveys undertaken every year since 1948. The committee recommends that the census after the next one, which will be the fourth post-war census, should be made and planned for 1957, and the fifth one for 1961. Sample surveys should be taken in years when no full census is made. The first post-war Census of Distribution was taken for 1951. The committee has recommended a full Census of Distribution once every 10 years with sample surveys every third or fourth year. A number of recommendations have been adopted which were designed to lower the cost and increase the value of the censuses, both to Government and industry. For example, the committee suggests that the exemption level below which firms need not make detailed returns in a full Census of Production should be raised, with certain exceptions, from 11 to 25 employees.

The Government's decision will be received with mixed feelings by industry. The burden of the evidence submitted by trade associations and professional bodies to the committee was that the censuses provide a great deal of extra work for a very small—some have said a negligible—return. From the point of view of official statistics the important arguments in favour of the censuses are that a regular periodic survey of the national economy is necessary for the formulation of economic and even of fiscal policy. It is also necessary to have an accurate check on a large amount of statistical data which is issued weekly and monthly, much of it based on intelligent estimates, and even on guesses. From industry's point of view, there is no doubt that there is a great deal of useful information which can be used for sales forecasting, for the formulation by the boards of companies of a view on the general trend of the economy within which a company's general policy must be worked out, and for economic intelligence work.

The main criticism of the new proposals is that the Government seems to have been particularly sensitive to the representations of retail trades, whereas it has made the fewest possible concessions to production industries. Companies making capital goods are to remain bound to a stringent cycle of returns for the Census of Production whereas the distributive trades—which are much more in need of study from the point of view of short-term fluctuations in demand—are let off comparatively lightly with a 10 years cycle of full-scale censuses with only one sample survey in between. The prescriptions are right but they have been handed to the wrong patients.

★ ★ ★

BOILER DESIGN AND AVAILABILITY

Before the war, boiler designers were turning their attention towards high steam pressures and temperature cycles in association with high ratings of the combustion chambers, stoker grates and heat transfer surfaces. The success of these improvements was, however, dependent upon the fuel used being supplied to a rigid specification, including ash content and fusion characteristics. Unfortunately, as is well known, during the war many boilers had to be operated on coals for which they were not designed; and the resulting formation of deposits and of corrosion raised the question of availability in an acute form. Since the war, too, it has become necessary to utilise coal containing a relatively high proportion of deposit-forming material for electrical generation, while increasing mechanisation in the main has led to the inclusion of more and more extraneous mineral matter. At the same time, the continued exploitation of higher pressure and steam temperature cycles has brought about the adoption of the unit-boiler system and consequently the employment of pulverised fuel firing. A high standard of availability is therefore more than ever necessary and its provision has necessitated much careful research and some interesting developments.

This was well brought out in a paper on "Boiler Design and Availability," which was read before the recent World Power Conference in Brazil by Mr. W. F. Simonson, and has now been reprinted by the Boiler Availability Committee, 8 Waterloo-place, London, S.W.1. Taking availability as a primary objective, its effect on boiler design is discussed and the influence of certain fuel constituents on the method of firing selected is outlined. The design of the combustion chamber, superheater, convection transfer surfaces and low-temperature heat recovery plant is described, the salient points being illustrated by reference to actual installations. As might be expected, cleaning procedures find a prominent place.

The pressure of the events referred to has caused a not altogether willing reversion from the pre-war trend towards a highly-rated boiler of low capital cost to a more liberally-designed unit with consequent increases in constructional and installation costs. The attainment of this end has, as Mr. Simonson makes clear, involved long-term investigations of great complexity but has not been altogether useless. It raises the hope that when the fuel position improves the work of the Committee will be carried on in, perhaps, more profitable directions.

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LESS U.S. DEMAND FOR CAPITAL PLANT

The so-called inventory recession in the United States has been remarkable for the small impact made upon the economic life of the country. President Eisenhower has described 1954 as the most prosperous peacetime year in U.S. history, even if "marred by the fact that in certain industries and localities some unemployment did exist as the aftermath of war and inflation." Personal incomes before tax are in aggregate somewhat lower than in 1953, but, due to large remissions, show no reduction after tax. Sales of durable consumer goods have fallen, but they had previously been somewhat over-inflated, and the public, despite the widespread talk of depression, have maintained a high level of spending. The danger that a deep slump may develop with world-wide repercussions still remains: a crucial factor is the level of activity which can be maintained in the capital goods industries.

A useful indicator is the state of the order book for heavy electrical plant. According to a recent article in *Business Week*, United States manufacturers of generators will achieve a record output of 15,000 MW in 1954, but orders booked for this type of plant, which takes 24 to 30 months to build and install, amount to only about 10,000 MW for 1955, and less than 3,000 MW for 1956. It is true that output in 1955 is still likely to be as high as in 1952, but since demand for electricity has in the past increased so rapidly in the United States as to double peak loads every ten years, plant requirements in 1955, should have been much higher than in 1952. It has hitherto been the policy of the United States electricity supply industry to maintain a reserve of capacity 15 per cent. above peak load, but assuming that the normal upward rate of electricity consumption continues, this reserve will quickly be wiped out, unless orders for new equipment are placed very shortly. The supply authorities, however, are far from confident that demand for electricity will increase and remember with anxiety slumps in the past when they had considerable idle capacity. In present conditions the cost of unused capacity would be about 125 dols. per kW per annum.

Orders for other types of capital plant are following the same trend as those for electrical generators. A recent Government survey of business investment intentions indicated that expenditure on plant and equipment would be about 26·7 billion dols. in 1954—6 per cent. less than in 1953. The decline is shared by most industries with the important exceptions of vehicles, paper and petroleum. It is, however, comparatively modest (aggregate investment in 1954 will be 194 million dols. higher than in

1953) and the survey suggests that despite a gradual fall, capital goods activity will in fact be an important sustaining force in the economy.

* * *

EXTENSIONS TO FAWLEY REFINERY

The first three years of operation have proved that the decision of the Esso Petroleum Company to build a large refinery at Fawley was justified. About 18·25 million tons of crude oil have been processed, and apart from supplying 27 per cent. of the total U.K. consumption of refined products, Fawley has been able to export 3·2 million tons valued at about £27 millions. The capital cost has, of course, been high—amounting to about £35 millions. Altogether the Esso Petroleum Company has had to find £95 millions in new capital, of which, apart from the expenditure directly incurred by the Fawley installation, £8 millions have been spent on tankers, £10 millions on marketing equipment and £32 millions for working capital.

The expenditure at Fawley has, however, resulted in important economies—not the least being a saving in hard currency of 2 million dols. per week due to the fact that a high proportion of refining costs had formerly to be met in dollars. Technical progress has largely overcome the disadvantages of a refinery in the consuming area rather than in the oilfields. One arises from the fact that crude oils have to be imported with widely varying contents, so that great skill is required in planning and technique to obtain products as economically as possible in the proportions required by the market. Such a high degree of flexibility has been obtained from the catalytic-cracking processes that a refinery can now produce a larger quantity of higher-priced products from a given quantity of crude, and can also adjust the balance of products to meet fluctuations of demand. This control will be further increased at Fawley by the new extensions which were announced last week. These are to cost £10 millions and are to include the construction of new plant known as a hydro-former. This will cost £4 millions and will have a capacity of 10,000 to 15,000 barrels per day of high-quality motor spirit (present capacity at Fawley is about 120 thousand barrels of finished products per day). This plant, together with such new units recently completed or under construction at Fawley as the sulphur recovery plant and the polymerisation plant (which enables high-octane fractions to be made from gases which would otherwise have to be burned under the stills) will ensure a degree of flexibility and economy unsurpassed anywhere.

* * *

MODULAR CO-ORDINATION

For many years now a programme of standardisation of engineering components, including building components, has been carried out by the British Standards Institution through its various committees. Although each committee has worked independently there has been some co-ordination aimed at relating the dimensions of differing products, but there has been no general attempt to develop a common dimensional basis. From within the building industry, however, there has arisen a movement for the overall co-ordination of dimensions of the components of building construction. This is to be done by bringing into general recognition and use a "module" or basic dimension. The principal dimensions of all components are to be simple multiples or sub-multiples of the module, and the plans of buildings would be drawn on a grid, the basis of which would also be the same modulus. In spite of considerable difficulties—including that of selecting and defining the modulus—considerable progress has now been made: in the United Kingdom modular co-ordination has been widely used in prefabricated construction, particularly for schools, and in Germany about 300,000 houses are said to be erected for a reasonable cost under a modular system.

In the United Kingdom, the subject is being studied by two groups, one set up by the British Standards Institution and the other, working along parallel lines, at the Building Research Station; care is taken to see that the work of these two bodies is carefully integrated to avoid overlapping. There also exists in this country the Modular Society whose main function is the dissemination of ideas relating to co-ordinated construction.

* * *

COLD STEEL STRIP EXPANSION

A further development scheme has been announced by the Steel Company of Wales for its Abbey Works at Port Talbot in South Wales. The cold reduction sheet mill is to be expanded to increase its output by about 2,700 tons per week. The scheme will cost about £1·5 millions and will take about 20 months to complete. The expansion involves only an extension of part of the cold reduction process. An additional four annealing furnaces with nine bases and a new cut-up line are envisaged and additional floor space and loading facilities will be included. It will not be necessary to extend the cold reduction mill itself and the hot strip capacity as already planned is considered to be sufficient to keep the new annealing plant in operation. An extra four steel furnaces are already scheduled for the Abbey Works melting shop and it is estimated that the latest technical developments to be incorporated in these will give a sufficient margin of output for the new annealing plant.

The Abbey Works provides hot rolled strip for cold reduction into tinplate at the company's steel strip works at Trostre in South West Wales. Cold reduced sheet at the Abbey Works finds its outlet direct to industry to such large users as the commercial vehicle manufacturers. Here is one further example of the growing dependence of the steel industry's prosperity on sheet products.

* * *

COMPUTING MACHINES

It has been suggested that the Industrial Revolution is entering a new phase, a phase in which machines will take over a growing number of the tasks at present performed by human physical and intellectual labour, and the development of automatic tools and handling equipment illustrates this tendency. The tasks which are most readily performed by mechanical agency are, in general, those which are by nature logical and systematic, and no procedure better fulfils this condition than routine mathematical calculation. The analysis of vast quantities of numerical data is essential to modern scientific and administrative techniques and it is not surprising, therefore, that industry is becoming increasingly dependent upon the automatic computing machine.

The problem of dealing rapidly with complex and lengthy calculations occurs in many fields, including, for example, the aircraft and catering industries, and in work of this kind methods of saving time represent not merely an economy, but in certain cases an actual condition of further progress and development. It has been estimated that "Tridac," a three-dimensional analogue computer designed to perform high-speed flight calculations, is equivalent in rate of working to a staff of 10,000 equipped with desk calculating machines, and consequently the cost of research now carried out with the aid of the computer would before its introduction have been prohibitive.

Tridac, which is described on a later page in this issue, is an analogue machine and therefore in effect a working model of the flight system which it represents. It is capable of high operating speeds and can be set so that calculations proceed at a rate corresponding to the real motion of the aircraft.

If is this action which distinguishes the analogue system from that employed in the digital computing machine, which does not simulate actual events but performs a series of mathematical operations in sequence. Although it is also rapid in operation, the digital computer could not, in the forms at present available, deal with the flight problems for which Tridac was designed; it has, however, wider application and, unlike Tridac, gives results with mathematical accuracy.

The scope of the digital computer and the current needs of design and research staffs have led Elliott Brothers (London), Limited, who were responsible for the construction of Tridac, to establish a computer service on a machine time-hire basis; it is claimed that the machines employed in the scheme will complete in one hour work which would formerly have occupied an operator using conventional methods for about two years. The consequent economy in skilled-mathematician man-hours and the relief from routine calculation will give technical staffs a new freedom to undertake a variety of investigations which have hitherto been impracticable in the time at their disposal.

* * *

MECHANISING THE OFFICE

The trend towards eliminating the need for office workers proceeds apace. A new machine developed in the United States by the Burroughs Adding Machine Co., is said to print and to record simultaneously at speeds unattained hitherto. The machine will prepare in one hour 27,000 pay slips, or 36,000 address labels (in duplicate), or 13,200 electricity bills, from various records. A punching mechanism, synchronised with the printing unit, ensures that all relevant facts are properly recorded on punch cards. The machine, made up of several units which can be varied to suit individual needs, is likely to find its principal applications in the offices of public utilities, publishing houses, mail order and insurance companies.

Meanwhile manufacturers continue to improve the types of machines available. International Business Machines Inc., have brought out the first all-transistor calculator, which is said to measure only about half the size and to need 5 per cent. of the power of a machine incorporating vacuum tubes. Although no faster than the vacuum-tube machine, the lower power requirements eliminate the need for forced air cooling of components, and maintenance costs are expected to be much lower as the transistor has a longer life than a tube or valve.

Another most interesting device, developed by Remington Rand Inc., consists of an automatic filing system, used by the Independent Life and Accident Company, which enables an operator to obtain any of 175,000 record cards in her section in a few seconds at the touch of a button. This is said to have saved the company 40 per cent. on clerks' salaries.

Letters to the Editor

THE ECLIPSE OF THE ENGINEER IN MANAGEMENT

Mr. Monck's Reply

SIR, In my paper to the British Association (ENGINEERING, September 10) I tried to show that engineers here had suffered an eclipse in management in the last fifty years; during this period, Britain had lost her lead in world trade in manufactured goods; and that these events had not been caused by any shortage in the number of engineers in Britain by comparison with other industrial countries, while the standard of qualifications had at least been maintained. All this amounted to an elaborate way of saying that in this country we needed a good engineering industry, and that we were not likely to get it unless good engineers had the running of it, a platitude of such blinding obviousness that I have not been seriously challenged in your correspondence columns, during the discussion at Oxford or indeed elsewhere.

Nevertheless, I hope you can find space for these points that seem to me to merit some further discussion. First, what contribution can an engineer (the right kind, of course) make to the board of an engineering company? Lord Halsbury suggests that engineers as engineers will have more to learn than contribute; but why pick on the technical man? Surely this is just as true of a solicitor as a solicitor, and even more of the General as a General, and a layman as a layman. The truth is that a board of an engineering company successful in world markets needs collective good judgment about human relationships, economic trends, and customers' requirements, and how to tie all this together into products that are apt to the time and can be profitably made. Chartered engineers, to become qualified as such and admitted to membership, need experience in all these matters, and yet are outnumbered by five to one as directors of the 725 public companies in the engineering industry I examined. Certainly others, too, can contribute, just as a butcher as a man can on occasion be a most constructive member of a borough council or of the House of Commons. I argued that the proportions of technical men to non-technical men were now the wrong way about; I still think so.

Secondly, some have implied that engineering (or science) is a narrow educational discipline. This may have some validity, but it can be equally true of classics, history, economics or what you like. Surely all specialisation is bad if too intense, too long endured or engendering too much pride in itself. In so far as it may arise more in engineering than other educational disciplines, the cause may well be, as I suggested, that the status of the profession is low: an engineer can advise but not command save at the purely technical level, a view Sir John Elliot seems to support. This view was held for years about the boards of the British railway companies; are they as successful in their field as the aircraft companies in theirs? (As I showed, the aircraft companies have the highest proportion of technically qualified directors.)

Finally, should anything be done about the state of affairs to which I have drawn attention, and by whom? The Chancellor of the Exchequer and the banker spoke complacently to one another about our foreign exchange position at the Mansion House recently; the crowds press admiringly around the glossy new cars at Earl's Court as new export records for the industry are announced. These events are front-page news; in the back pages the Board of Trade disclosed that in the first six months of 1954 world trade in manufactured goods expanded by 6 per cent., but our share by only 5 per cent. Thus the trend since 1950 is continuing, and with it the danger to our standard of living.

Neither the Government of the day nor the individual engineer can do much; if the eclipse of the engineer in the management of our engineering industry is to end, some six hundred boards must act. An examination of the character of the inevitable changes, and of our share in world trade in two or three years time, will give us the first clue.

Yours faithfully,
BOSWORTH MONCK.

19, New Bridge-street,
London, E.C.4.
October 25, 1954.

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MOLYBDENUM DISULPHIDE

Success as a Simple Lubricant

SIR, I was glad to gather from Mr. G. J. Vineall's letter which appeared in your issue of October 15, that he largely corroborates many of the findings regarding the great variety of applications of molybdenum disulphide as a lubricant.

I would assure him, however, that optimism played no part when I ventured to suggest that a MoS_2 surface skin can be relied on to prevent metal to metal contact under severe conditions and over considerable periods of time. The type of material used and the technique of application have, of course, an important bearing on whether or not a specific problem can be solved by this means.

Mr. Vineall relates his experience that molybdenum disulphide is of value in preventing wear or pick-up under light loads while under high working pressures or long and continuous service, the surface skin needs replenishment.

Contrary to that, it has been the writer's experience that heavy loads are, if anything, more favourable than light ones, probably because they tend to drive the adsorbed MoS_2 particles further into the metal, resulting in more complete re-orientation of the crystal laminæ and a better bond. This was outlined in the article which appeared in ENGINEERING of August 6, 1954, page 171. In fact, the use of the maximum practicable running-in pressure after the application is often a wise precaution to ensure proper contact and bonding, especially if operational loads are deemed too light to serve this purpose. This has been borne out by the investigations of Prof. G. Spengler, Munich "Zeitschrift des Vereins Deutscher Ingenieure (June 11, pages 506–512 and July 11, pages 683–687).

That on many jobs it will be necessary to provide for replenishment of the film is not in question, and the writer has also resorted to the use of colloidal dispersions of MoS_2 as additives to conventional lubricants with success.

The success of the material used by us as a "break-in" lubricant for slides, bearings, gears, etc., also seems to provide evidence that it can successfully sustain the very high point loads involved. The better and safer mating of machine members run in with molybdenum disulphide and the retention thereby of surface condition of a high order is undoubtedly due to the film strength of the adsorbed skin. Thus the high spots are probably being "ironed-down" under pressure, i.e., the metal is made to flow, protected by the MoS_2 coating.

The loads which protected high spots are required to sustain during running-in probably exceed calculated bearing pressures ten times or more, as the actual bearing areas in contact to start with often amount to less than 10 per cent. of the whole surface. This appears to be valid evidence in support of the writer's "high-load" contention.

The success of the material in cold forming and drawing operations is further evidence of this, as surely the pressures generally involved can hardly be described as light. The use of a 70 per cent. concentration of molybdenum-disulphide in a suitable carrier, Molykote type G, recently enabled a large press shop to make use of about 10 tons of strip of 140 Brinell hardness instead of 105 Brinell as specified for the job.

It would thus appear that in many difficult drawing operations, it is less a question of finding material sufficiently ductile to flow freely, than a question of using a suitable lubricating medium.

In regard to Mr. Vineall's doubts as to the ability of "simple surface treatment" with this material to prevent metal-to-metal contact for considerable periods of time, I should like to mention three instances to demonstrate the point.

(1) The development engineer of another press shop reported recently: "....the press tools... become impregnated after the first application and run for a considerable period without further attention, and this application alone is of considerable interest to us..."

(2) At a third press shop, the writer was recently shown smears of Molykote type G on press tool pillars (guide pins) which, as he was informed, had not been renewed since the start of the batch "more than 400,000 strokes ago," and were still effectively in being, preventing metal to metal contact. Owing to close tolerances and probably neglect in maintenance, a good deal of scuffing and scoring had been experienced before.

(3) This concerns open gear lubrication: A manufacturer of escalators and lifts, after prolonged experimentation with open gear lubricants of all types, has for some time now standardised on the use of Molykote type G for use on all gearing.

One of the most troublesome escalator installations was singled out for tests. After the application of Molykote type G, the gears were left without relubrication for seven weeks. On examination, no signs whatever of galling or wear were found, which had previously occurred frequently.

I would assure Mr. Vineall that in spite of the optimism he reproaches me with, our attitude is also one of caution and of disbelief in universal remedies.

However, when definite results are achieved with material prepared and applied in a suitable manner, it would appear to be in the common interest to ventilate the advance in technique which it represents. All the answers may not yet be known, and in one of the most promising fields, the treatment of cutting tools with molybdenum disulphide, recent trials having shown very good results.

It is hoped that all engaged in the study and use of molybdenum disulphide for the many applications where it can solve what are often long-standing problems, will regard the matter as one of common technical interest.

Yours faithfully,
H. R. GOLDIE.

K. S. Paul, Limited,
Gt. Western Trading Estate,
Park Royal-road, N.W.10.
October 26, 1954.

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ARMAMENT RESEARCH AND DEVELOPMENT ESTABLISHMENT

The Ministry of Supply have announced that the Armament Research Establishment, centred at Fort Halstead and Woolwich, and the Armament Design Establishment, centred at Fort Halstead, are being amalgamated to form the Armament Research and Development Establishment. The present separation of research from development and design, it is emphasised, is arbitrary and artificial and, in fact, the two establishments have worked in close association for a long time.

The director of the new establishment will be Professor Ewen M'Ewen, M.Sc.(Eng.)(Lond.), M.I.Mech.E., who is at present Professor of Agricultural Engineering, King's College, University of Durham.

The task of the new establishment will be to further the research work and the development and design of weapons which are the responsibility, within the Ministry of Supply, of the Controller of Munitions, Lt.-General Sir John Eldridge, K.B.E., C.B., D.S.O., M.C. It will continue to undertake the kind of work which hitherto has been done at the two establishments for all three Services.

PERSONAL

SIR LEONARD LORD, K.B.E., chairman and managing director of the British Motor Corporation Ltd., has been made vice-president of the Institution of Production Engineers, 10 Chesterfield-street, London, W.1, and President-elect of the Institution. Sir Leonard will take up office as President on July 1, 1955.

DR. RICHARD BEECHING has been appointed chairman of the Metals Division of Imperial Chemical Industries Ltd., in succession to MR. C. E. PROSSER, who is retiring from the company's service. The appointment dates from February 1, 1955.

LT.-COL. D. W. R. WALKER, M.B.E., B.A., late Royal Engineers, has joined Flexible Drives (Gilmans) Ltd., Carlton House, 195 High-street, Smethwick 41, Staffordshire, on leaving the Regular Army, as joint managing director.

MR. R. J. H. BRANTHWAITE, B.A., A.M.I.E.E., has been appointed superintendent of the new electronic division of the development laboratories of R. B. Pullin & Co. Ltd., Phœnix Works, Great West-road, Brentford, Middlesex.

MR. HERBERT PRIEST has been elected chairman of the board of Walter Spencer & Co. Ltd., Crescent Steel Works, Warren-street, Sheffield 4, in succession to MR. E. RANSOM HARRISON who has relinquished the position owing to ill-health.

MR. V. HARBORD, A.R.S.M., F.R.I.C., M.I.M.M., and MR. T. G. HOWARD, F.R.I.C., M.I.M.M., of Riley, Harbord and Law, Parliament Mansions, Abbey Orchard-street, Victoria-street, London, S.W.1, announce that MR. W. A. C. NEWMAN, C.B.E., B.Sc., A.R.S.M., A.R.C.Sc., D.I.C., F.R.I.C., F.I.M., M.I.M.M., who has retired from his position as chemist and assayer of the Royal Mint, joined them as a consultant on November 1.

MR. S. A. CLARKE, B.Sc.(Eng.), D.F.H.(Hons.), M.I.E.E., has been appointed electrical engineer (construction) to the London Division of the British Electricity Authority, Generation House, Great Portland-street, London, W.1.

LIEUT.-COL. HARRY GRESHAM has been appointed director and London manager of Gresham and Craven Ltd. Pending the opening of offices at 15 Whitehall, London, S.W.1, all inquiries and letters should be addressed to the firm, at Ordsall-lane, Salford 5, Manchester (Telephone: Deansgate 6061), or 14 Great Peter-street, London, S.W.1 (Telephone: ABBey 5964).

MR. A. W. EVANS, at present manager, Birmingham area, for Air Control Installations Ltd., has been appointed general sales manager at the firm's head office, at Ruislip, Middlesex. The Birmingham office will be managed, in future, by MR. W. LENNON.

MR. J. R. QUERTIER, B.Sc., A.C.G.I., A.F.R.Ae.S., has joined the Consolidated Pneumatic Tool Co. Ltd., at their head office in London, at 232 Dawes-road, S.W.6. He will be engaged in the development of existing products and new lines.

MR. G. R. BUCKLEY, formerly general manager, furnaces, at the Stanton Ironworks Co. Ltd., Stanton-by-Dale, near Nottingham, has been appointed general works manager. Other appointments include that of MR. E. MORGAN, formerly chief metallurgist, who becomes general manager in charge of research; that of MR. L. RAWLINS, formerly export manager, who has now been appointed commercial manager; and that of MR. J. D. HICKMAN, who formerly held the position of assistant export manager and now becomes export manager.

MR. K. A. MACLEAN, B.Sc.(Eng.), A.M.I.Mech.E., until recently assistant to the general works manager, Northern Aluminium Co. Ltd., has been appointed head of the fabricating division of Aluminium Laboratories Ltd., Banbury, Oxfordshire.

MR. FRANK WHITEHOUSE has been appointed by Newton, Chambers & Co. Ltd., Thorncliffe, Sheffield, general works manager of the heavy construction department. MR. S. B. RIPPON, general sales manager, will be responsible for the sales promotion and supervision of all department products, and MR. K. SHEARD, as contracts manager, will be responsible for all technical and commercial obligations. MR. W. A. LEAVER, chief of engineering, will be responsible for the control of all design for production and the direction of the drawing offices.

MR. B. C. WILKINS retired under the age limit from the position of chief accountant of W. T. Henley's Telegraph Works Co. Ltd., on October 31. His successor is MR. S. H. NUNNERLEY.

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BUSINESS CHANGES

ARMOUR & CO. LTD., London, will sell next year the range of chemicals, including the new types of cationic and nonionic chemicals, now made solely by Armour & Co., Chicago. A new production plant is being built at Littleborough, near Rochdale, Lancashire, by MESSRS. HESS PRODUCTS LTD., who have signed a contract with royalty payments to Armour & Co. Chicago, for which they have the exclusive manufacturing rights for the new process and future developments. Sales and distribution, both for the home market and export, are exclusively in the hands of Armour & Co. Ltd., Chemical Division, Lindsey-street, London, E.C.1.

A factory on the Team Valley Trading Estate, Gateshead-on-Tyne, has been leased to the DUNLOP RUBBER CO. LTD. for the manufacture of industrial rubber goods and allied products.

To meet the increasing world demand for citric acid, JOHN & E. STURGE LTD., of Birmingham and Selby, Yorkshire, and MERCK & CO. LTD., Canada, have jointly formed a new company in Canada, known as STURGE (CANADA) LTD. Manufacturing plant for the new company is now under construction at Valleyfield, Quebec, and is expected to be in production early next year.

SHAW PROCESSES LTD., 25 Clyde-vale, Dartmouth-road, Forest Hill, London, S.E.23, producers of precision casting refractories and other foundry materials, have formed a new company, in association with VERICAST LTD., of Victoria, to be known as SHAW PROCESSES (AUSTRALIA) PTY. LTD., Victoria, Australia. The directors are MR. CLIFFORD SHAW, MR. NOEL SHAW, COLONEL PETER CHANCE (chairman) and MR. KENNETH SPENCER.

A new company, A.P.V. (IRELAND) LTD., has been formed by agreement between BOOTH BROTHERS LTD. and THOS. PEARSON & CO. LTD., both of Dublin, and the A.P.V. Co. LTD., Wandsworth Park, London, S.W.18. The new company will commence to manufacture all stainless steel equipment in a factory at Drimnagh, Dublin. The directors of the new company are MR. R. C. BOOTH, MR. B. E. BOOTH, MR. E. M. BOOTH, MR. W. H. JONES and MR. R. M. D. ODGERS.

B.S.A. TOOLS LTD., Mackadown-lane, Kitts Green, Birmingham 33, have been appointed sole representatives for the whole of Canada, for the abrasives division of the ELGIN NATIONAL WATCH CO., Elgin, Illinois, U.S.A.

ALFRED HERBERT LTD., Coventry, THE COVENTRY GAUGE AND TOOL CO. LTD., and TAYLOR, TAYLOR & HOBSON LTD., announce that as from November 1, the first-named company will co-operate with the other two, in the United Kingdom, in the sale of their engineers' measuring instruments. Alfred Herbert Ltd. already handle the sales in the United Kingdom of HILGER & WATTS LTD., and SIGMA INSTRUMENT CO. LTD., and all these companies will work closely together to provide a complete and comprehensive range of measuring instruments.

A new company, RUBERT & CO. LTD., Chapel-street, Stockport-road, Levenshulme, Manchester 19, has been formed for the purpose of manufacturing precision instruments and gauges.

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Contracts

NAPIER ELAND PROPELLER TURBINES

A contract has been signed between D. NAPIER & SON LTD., a member of the English Electric Group of Companies, and the Convair Division of the General Dynamics Corporation of America, for the purchase by the Napier Company of a Type 340 Convair-Liner. This aircraft will be fitted with Napier Eland propeller turbines and, after flight testing, the new airframe/engine combination will be demonstrated to air-line operators in Europe and North America. When flight trials have culminated in the granting of a Certificate of Airworthiness, existing operators of the Convair-Liner 340, which is in wide use on air lines throughout the world, will be able to take advantage of the economies and passenger appeal (quietness and lack of vibration) of turbo-propeller operation without having to re-equip with new aircraft. Early in 1955 Napier Eland engines will be installed in one of the prototypes of the Elizabethan air-liner. British European Airways, who operate a fleet of these aircraft, are following this project with interest. The Napier Eland is now producing more than its designed power of 3,000 e.h.p. and a version of the engine with the power output increased to at least 4,000 e.h.p. is already being developed.

Radio Equipment. A further step has been taken by the British Broadcasting Corporation in their plan to provide nation-wide coverage with the Home, Light and Third Services by a chain of very-high frequency frequency-modulated broadcasting stations. MARCONI'S WIRELESS TELEGRAPH CO. LTD., Chelmsford, Essex, have received an order for 24 combining units and 24 feeder changeover switches, with the associated connecting feeders. This comprises equipment for six three-programme stations. In addition, the firm have been awarded a contract for similar combining units to be installed at Wrotham.

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THE PARSONS MEMORIAL LECTURE

Steam Turbine Development

The nineteenth Parsons Memorial Lecture was delivered at the Institution of Mechanical Engineers last Friday, October 29, by Mr. F. Dollin, B.Sc., M.I.Mech.E., Chief Turbine Designer, C. A. Parsons and Company, Limited. The Lecture was instituted in 1935, under the auspices of The Royal Society to be delivered each year in one of the many branches of science to which Sir Charles Parsons contributed, and to be sponsored by the Institution or Society appropriate to that subject. Since, however, this year is the centenary of Parson's birth on June 13, 1854, it was most fitting that the venue should have been the "Mechanicals" and the subject "Factors Influencing the Continuing Developments of the Steam Turbine," thereby commemorating the most significant of Parson's many achievements—the development of the steam turbine.

Mr. Dollin began his Lecture with a reference to a radial-flow turbine which Parsons had built himself in 1890, in order to examine the fundamental nature of the turbine, and followed this with descriptions of equipment which had since been made to examine blading. This equipment included the static nozzle tester in which the nozzles were suspended in such a way as to enable the reaction of the jets to be measured both axially and tangentially, so that the mean efflux angle of the jets could be at once determined. The use of air instead of steam as the working fluid assisted greatly in the simplification of the design and of the problems being examined. Since static tests could not completely replace tests on a multi-stage turbine, a seven-stage reaction turbine had now been built at the author's works for further observations; particular care had been taken over the design of the casing and the location of the pressure-measuring points so that a true picture could be gained of the effective static pressures existing at the inlet to the first stage and the outlet to the last stage.

Trends in turbine design, as influenced by power requirements, were then considered and brief details and figures were given in respect of some machines recently completed or still to be delivered. An important fact was the greatly improved reliability of steam turbines so that boiler availability (that is, effective working hours before maintenance) was comparable with the turbine; the logical outcome of this would be boiler-turbine units, all cross-connections between boilers being eliminated with great simplification of plant layout. Future developments, however, were likely to be limited by the constructional materials which were available and the lecturer concluded with a review of recent metallurgical advances. Particular reference was made to the chromium-molybdenum-vanadium steels now being produced to eliminate creep at temperatures of the order of 1,000 deg. F., but unfortunately these steels exhibited no better resistance to oxidation than alloys already in general use.

Before Mr. Dollin read his paper he was presented with the Parsons Medal by Sir David Brunt, secretary and vice-president of The Royal Society, and afterwards the vote of thanks was proposed by Mr. A. C. Hartley and seconded by Professor Edmund Giffen. Following the Lecture, the chairman, Sir Claude Gibb, M.I.Mech.E., and the directors of C. A. Parsons and Company, Limited, gave a dinner to mark the centenary of the birth of Parsons.

PRESSURE DIE CASTINGS IN INDUSTRY

Extending their Fields of Application

Speaking on the subject of "Productivity and Pressure Die Casting," at the first International Pressure Die Casting Conference, held in London from October 25 to 28, Mr. F. G. Woollard, M.B.E., M.I.Mech.E., M.I.Prod.E., chairman of the Zinc Alloy Die Casters' Association, said that the conference had been convened for the purpose of debating methods for increasing the range, the scope and the distribution of die castings which could now be made in alloys of six metals, namely, aluminium, copper, lead, magnesium, tin and zinc, thus covering all casting requirements except those in which ferrous alloys were indispensable. Die casting was essentially a home industry which had virtually nothing to fear from extra-territorial competition; on the other hand, the exchange of information between countries was of the greatest value.

The motor-car industry was the best customer for both zinc and aluminium die castings, but an endeavour should be made to enlarge the range of these castings in other directions. This was, in the order of their current demand, domestic appliances, components and equipment for machine tools, photographic and scientific apparatus, builders' hardware, and office machinery and equipment. Electronic and electrical control devices and, with the growth of automatic equipment, small hydraulic and pneumatic apparatus, should also receive careful consideration as possible rapidly-expanding fields for the application of pressure die castings.

It must be recognised that the trend was towards the production of larger and more complicated die castings. This should be greatly to the advantage of die casters since the saving on machining made die castings so attractive that even considerable expenditure on dies would not deter the end-product manufacturers.

Die casters could assist the development of their industry by ensuring that they delivered high-quality products. There were, however, other matters to be considered and one of the most important was that of plating. Nothing was so detrimental to the good name of zinc as motor-car door furniture (grasped every time an owner entered or left the vehicle) which was unpleasant to handle because the plating was in bad condition. In the best interests of die casting this problem called for a speedy solution.

Another matter in which the individual die caster should be interested was that of accuracy in estimating. Close quotations had a good moral effect on a client. On occasion, however, variations in the estimated weight of material had shown differences as high as three to one and, in high-cost materials, such as those used in die casting, this made price variations that were preposterous. Furthermore, carefully worked out machine rating was essential for accurate estimating.

It could be said without fear of contradiction that, as soon as the demand for any commodity rose to what might be termed a repetitive rate—and this differed for every commodity—the end-product designer would be open to consider the possibility of die castings for every suitable application. The touchstone here was the economic quantity and it was for the die caster and his technical staff to maintain a questioning attitude in all markets to determine when their services could be usefully offered to those entering the repetitive phase of their operations; and this not necessarily in the vast quantities characterised by some industries. The American die casters excelled in creating a demand for their products. Every new domestic appliance was studied for re-design to embody die castings, and the maker of the end product was approached not only with a new proposition but was also furnished with quotations for the proposals put forward.

THE WORK OF THE SUPERVISORY ENGINEER*

DUTIES UNDER VARYING CONDITIONS

By Bryan Donkin, B.A., M.I.E.E.

The general outlines of a project having been decided, the duties of the supervising engineer are to ensure that the work is done properly, promptly and economically, there being a small degree of priority in that order. On the site he must begin with an investigation of the land available to accommodate the equipment and of the ground conditions, so as to discover whether special foundations will be necessary. He must then programme the work and check the expected times of delivery and the periods required for construction.

WORK ON SITE

In all but the smallest projects there is preparatory civil engineering work; and the supervising engineer is responsible for the contractor setting it out correctly. He must see that the foundations are excavated to the desired depths and that the materials used are in good condition and properly prepared. Since on work of this nature the whole of the manufacture is done on site, supervision must be practically continuous. When the site works have reached an appropriate stage the supervising engineer must advise the plant manufacturers that their equipment can be delivered and will urge this forward where necessary. It is, in fact, essential for regular checks on the progress at the manufacturer's works to be made.

As erection proceeds it will be necessary for him to keep an eye both on the progress of the work and on the quality of the workmanship. It is his responsibility to interpret the drawings, to ensure that the various works connect together without trouble and to avoid one firm's progress interfering with that of another. Inspection and testing on site of assembled equipment may also be one of his duties. During the whole period of construction, too, he must be concerned with the checking of costs, making measurements of quantities of civil engineering materials and certifying and passing invoices.

Turning to details of various constructional schemes, Mr. Donkin pointed out that it paid handsomely to carry out the civil engineering work connected with outdoor substations during the summer months, as frost prevented concreting and building, and draining might be required. An outdoor substation consisted mainly of circuit-breakers and transformers which had to be connected to the control and operating room and to the protective gear by multi-core cables. All this wiring must be rigorously tested to ensure correct operation; and it was advisable that these tests should simulate both normal operating and fault conditions by passing heavy currents at low voltage through the primary connections and bus-bars.

A THERMAL STORAGE STATION

Mr. Donkin then gave some details regarding the supervision of the operation of a thermal-storage electric generating station containing two back-pressure and two condensing turbines. This station was commissioned in 1949 and provided both electricity and steam for the linoleum factory of Jas. Williamson and Son, Limited. To balance the varying demands for heat and electricity four methods were available: excess steam was passed to an accumulator; condensing sets were used; make-up steam was obtained through a pressure-reducing valve; the pressure in the low-pressure steam mains was altered; and non-essential electric or steam loads were cut off by ripple control. In addition to balancing demands the controls had to maintain the correct pressure and temperature in the supply to the works, so that the steam arrived at the heating applicances in a dry-saturated condition.

Both pressure and pendulum governing were provided, the former striving to maintain a constant back-pressure in the steam mains so that the electrical output varied in proportion to the steam load. It could only be used where some external stable speed control was available, such as running in parallel with the British Electricity Authority's system. If it were desired to operate independently of the Authority the pendulum governor, which was primarily a speed controller, was used to maintain a steady frequency. Under these conditions the electrical load determined the amount of back-pressure steam available and hence its pressure. If more steam were needed it was drawn from the high-pressure mains through the reducing valves. If there were surplus steam it could be absorbed in the accumulator. If more electricity were needed this could be obtained from the condensing sets. The greatest economy was obtained when the heat and electricity supplies were balanced. Small variations of load could be dealt with by altering the back-pressure. This could be done within fairly wide limits as the back-pressure steam was used mainly for heating.

DISTRICT HEATING

Describing the method of control utilised in the Pimlico District Heating Scheme, which, when completed, will serve a population of 20,000 people, the speaker pointed out that the first duty of the control engineer was to check the number of therms in the hot-water accumulator, which contained about the day's consumption of heat. These therms were then brought up to the number likely to be required during the next 24 hours by running the back-pressure sets in the Battersea power station. Temperature distribution was controlled by six resistance thermometers in typical flats on the estate and was maintained at not less than 65 deg. F. in the sitting rooms. The temperature was adjusted by varying the temperature of the hot water in accordance with the external air temperature, an adjustable thermostatically-controlled valve, which mixed a proportion of the cool return water with the hot water, being used for this purpose. The indoor and outdoor temperatures were continuously recorded so that trends could be observed and both excessive and insufficient heating prevented.

CONDITIONS IN THE TROPICS

In the tropics the duties of the supervising engineer set out above became more onerous owing to the distance from the home base and the unskilled native labour. Considerable improvement in packaging was important so that the equipment was adequately supported in its box and was protected from moisture and salt-laden atmospheres. Bright metal parts should be dipped in some form of protecting solution. This was particularly necessary with such items of equipment as the thrust pads for turbine bearings where the absence of rust inhibitor and lack of care in packing might result in the face being so marked as to be unusable.

In conclusion, it should be recorded that the supervisory engineer had an onerous and responsible duty. He had not only to see that the plant and equipment complied with the specification in quality and performance. He must also see that the client's engineers, to whom he handed it over ready for use, knew how to run it smoothly and efficiently, so that the full potentialities of the design were realised.

* Presidential Address delivered to the Association of Supervising Electrical Engineers on Tuesday, October 26. Abridged.

TECHNICAL EVIDENCE AT THE COMET INQUIRY

Continued from page 549

The Court of Inquiry on the B.O.A.C. Comet air liner crashes resumed on Monday, October 25. Sir Arnold Hall was recalled to help clear up questions arising from errors in the manuscript and during this Sir Hartley Shawcross asked him about cracks in the Comet fuselage.

Sir Hartley: Inevitably this question of the cracks has really got quite out of its context in some of the reports in the newspapers, and some impression has apparently been created that the cracks had a really significant bearing on this accident.

When Sir Arnold suggested that he had not quite said that, Sir Hartley asked him, "Crack or no crack, you would have expected fatigue at sometime around about this period?"

Sir Arnold: Yes. The aeroplane nad then exceeded the safe fatigue life and there was the possibility of fatigue occurring at that life.

Lord Cohen, presiding over the inquiry, then referred to a more suitable manufacturing process which might have eliminated such cracks. Sir Hartley said, "That has actually been done."

Sir Hartley: In the early stages in the production of the early aircraft some of this work was done by hand. Later it was done by a rubber pressing machine which distributed stresses more evenly and would, we think, have eliminated any cracks. In view of what has since been discovered about the strength of the pressure cabin, in the future stronger materials would have to be used, and with stronger materials the presence of cracks of this kind would have been much less significant.

Sir Arnold: I would agree with that immediately.

ENGINES FUNCTIONED NORMALLY

Just before the court adjourned for lunch Mr. Eric Stanley Moult, of St. Thomas' Drive, Hatch End, Pinner, the chief engineer of the de Havilland Engine Company, Limited, took the stand.

He said there was no evidence of abnormal functioning of any of the four engines prior to the accident. All the engines were very badly damaged on impact with the sea but they were led to the conclusion that there was no abnormal functioning by the fact that there were no signs of any seizure and no undue signs of heat.

Mr. Moult said he did not think there was much doubt that the engines of Yoke Peter were upside down on their final contact with the sea. Certain parts of the engine cowling had been almost moulded on to the tops of the engines by that impact.

Asked if he agreed with Sir Lionel's statement in opening that the engines could be given a clean bill of health, Mr. Moult said he agreed that the whole evidence indicated that the engines in no sense were the prime cause of failure.

The inquiry adjourned until Thursday, to allow members of the court to visit the Royal Aircraft Establishment at Farnborough to examine in detail parts of the wreckage and to see how the investigation was carried out.

When the court resumed on Thursday, Mr. J. M. Shaw, representing the relatives of some of the victims, questioned Mr. Eric Newton, Chief Investigating Officer of Accidents Branch, Ministry of Civil Aviation, about methods of repairing cracks which were discovered in the air frame.

Mr. Shaw: I understand that you do not think it a safe procedure to remedy cracks in any part of the pressurised cabin by drilling holes and leaving them?—Mr. Newton: Yes, that is my opinion.

Mr. Newton said when any cracks were reported in Yoke Yoke, the holes were repaired by drilling and riveting. Special checks were made to the B.O.A.C. Comet fleet after the Elba accident.

Answering Sir Hartley Shawcross, Mr. Newton agreed that it depended on the degree of stress concentration where the crack was whether it was likely to prove dangerous or not.

Air Chief Marshal Sir Frederick Bowhill, Chief Aeronautical officer to the Ministry of Transport and Civil Aviation and chairman of the Air Safety Board since it was established, explaining the duties of the Board, said "We keep under review all matters which we consider of importance in civil aviation on the British side. The Board can take up any question on its own."

Sir Frederick said that the Board adopted a minute stating: "The Board realise that everything humanly possible has been done to ensure that the desired standard of safety has been maintained."

Mr. Shaw: When the Air Safety Board passed their recommendation what did the Board consider to be the probable cause of the Elba disaster?—Sir Frederick: We did not know.

Mr. Shaw: At your meeting were any theories put forward as to what might be the cause?—We considered every point we possibly could.

Mr. Shaw: Did they include the possibility of failure of the pressure cabin?—Yes.

Mr. Shaw: You rejected it altogether as a possibility?

Sir Frederick: We did not reject anything, but we did not consider it was a possibility.

Mr. Shaw: You put that one possibility on one side?—Yes.

Mr. Shaw: Did that also include the danger of metal fatigue?—No. There is always danger of metal fatigue.

Mr. Shaw: Was that a possibility which you thought was an important one?—Yes, very important.

Mr. Shaw: What modifications were introduced which satisfied you that it had eliminated that danger?—There were over sixty modifications. Certain of them strengthened up the various parts of the aircraft.

Mr. Shaw: At the time you passed the minute, it remained that the cause of the Elba crash might have been due to some defect in the design or manufacture of the aircraft?—We did not think so.

If you did not think it was, what did you think it was due to?—We did not know. We thought that the modifications that were introduced would cover all the points which were humanly possible to prevent any further accidents.

Except fatigue? asked Mr. Shaw, to which Sir Frederick answered: Not necessarily. I think some of the modifications helped in the question of fatigue.

Mr. Shaw then went on to question Sir Frederick about the accident to a Comet at Calcutta with its consequential report from an Indian Tribunal which inquired into the crash.

Were you satisfied that the Calcutta crash was due to storm damage? he asked, and Sir Frederick replied: We considered it, as you see in the minute to the Minister.

Mr. Shaw: Did you accept at your meeting that the findings of the Indian court were correct or did you have doubts as to the correctness of their findings?—We considered the report very carefully and thought that they had come to a conclusion which was most likely to be correct.

Mr. Shaw: As a result of the advice which Sir Arnold Hall (Chief of Farnborough Establishment and a member of the Air Safety Board) gave you, were you satisfied that the Comet crash was purely due to weather conditions or did you have any doubts that it might have been due to some defect in the aircraft?—We considered that it was the most likely cause.

But you were not certain about it?—I have told you "No." We were not certain about it.

Sir Hartley Shawcross, Q.C., for the de Havilland Company: Having available to it all the information about the construction of the Comet and details of the tests to which it had been submitted, your Board calculated it was safe for Comets to fly again?

Sir Frederick: Yes

Sir Hartley: It is very easy for Mr. Shaw to be wise after the event but in the state of knowledge at the time of your recommendation were you honestly satisfied that everything possible to ensure safety had been done?—Yes.

Mr. R. A. McCrindle (for the British Airline Pilots Association): You regarded metal fatigue as a very important danger?

Sir Frederick: We always have done.

In reply to further questions Sir Frederick said: We considered that everything humanly possible that should be done had been done.

Mr. McCrindle: Looking back don't you think that this expression "Everything humanly possible has been done" is putting it much too highly?

I do not think so.

Mr. McCrindle: Had you known that the Comet Yoke Peter (the Elba aircraft) had on it at various points manufacturing cracks, would you have been perturbed in any way? Sir Frederick: I have told you that I have no engineering knowledge.

Sir Hartley Shawcross: When you recommended that Comets should fly again had there, in fact, been very elaborate tests to the tailplane at Farnborough and had these produced satisfactory results?

Sir Frederick: I did hear about that.

Sir Hartley: And that the Royal Aircraft Establishment felt safe to eliminate the tailplane as the cause of the disaster? Sir Frederick: Yes.

Sir Lionel Heald, Q.C. for the Crown (to Sir Frederick): It has been put to you that fatigue is always a possible cause of an aeroplane accident. No one will dispute that?—No.

Sir Frederick added in the course of his replies to further questions by Sir Lionel: "There is always a possibility of fatigue but you cannot ground every aircraft on that account."

DEFECTS AND REMEDIES

Charles Abel, Deputy Operations Director of B.O.A.C., of Sutton Avenue, Slough, gave details of the defects which had occurred during the life of the Comet Yoke Peter.

Altogether some 82 defects were listed but none of the faults could have caused any undue surging of the pressure in the cabin or raised the cabin pressure above 8¼ lb. per square inch, because a safety valve was fitted.

The defects were really corrections and adjustments which had been made to apparatus in the normal course of events, and were the type of defects one expected in a highly automatic pressure-control system.

Dealing with cracks which had been located in non-pressurised areas, Mr. Abel said he thought they were caused, in the main, by the jet efflux and buffeting which that part of the fuselage received. They were, broadly, behind the pressure dome and extending as far as the tail cone, the majority being on the underneath part.

He believed they were due to buffeting from the jet engine efflux caused on the ground or when the plane was close to the ground during take-off.

Mr. J. P. Graham, Q.C. (for the Crown): How did you regard them from the point of importance?

Mr. Abel: First of all as merely minor cracks and we repaired them as such, but in view of their number and frequency we discussed them with de Havilland with regard to repairs to the whole of the area.

Turning to cracks and defects in the pressurised areas of the plane, Mr. Abel said the manufacturers had requested that any damage in such parts should be referred to them so that they, in turn, could propose a suitable repair scheme. The particular areas where this procedure was recommended were round the cut-out areas of the pressurised fuselage and round the passenger entrance door.

Dealing with Yoke Yoke, the Naples aircraft, Mr. Abel gave details of inspections carried out from time to time and he said that on one occasion the aeroplane had suffered a fairly severe lightning strike as a result of which there had been a static discharge along the top of the fuselage resulting in seventeen minute burn holes which were afterwards repaired.

Mr. Abel said that eventually six possible reasons for the likely cause of the Elba accident were considered: control flutter, caused by control surfaces becoming loose and vibrating; primary structural failure; flying control failure; failure in some of the control circuits; fatigue, and particularly wing fatigue; explosive decompression of the cabin; the possibility of malfunctioning of the engines or installation leading to fire or major structural failure. Modifications were introduced to cover these various contingencies.

Mr. Abel said that fatigue tests on specimen parts had been going on at the de Havilland company for a considerable time. Prior to the Elba accident there had been a great deal of discussion on the subject of wing fatigue. About the time of the Elba accident the first cracks were beginning to show on the test aeroplane—the prototype at Farnborough.

Mr. Abel said a number of modifications were incorporated into the Comet electrical system. One of the aircraft, Yoke Sugar, was run under load for many days to test its electrical system and simulate various faults, which could provide the source of ignition to inflammable vapour.

Precautionary modifications were made. Modifications were also made to prevent fluid leakage which might also have been a cause of explosion.

The inquiry adjourned until Friday.

Mr. Charles Abel, deputy operations director, B.O.A.C., continuing his evidence before the Comet inquiry on Friday, was closely questioned by Mr. James Shaw, appearing for relatives of Comet disaster victims.

He was asked about the practice of drilling holes at the end of cracks in the fuselage of Comet aircraft and plugging them with rivets. He explained that the practice was to drill a hole at the end of the crack and in this way prevent the crack running further.

Mr. Shaw: Is any sealing process then done?—The sealing process is putting the rivet in. These would be quite small cracks.

Would you consider that the wise way to deal with a crack?—It depends where the crack is.

We know now that cracks which have been stopped

in that way have in fact spread. Is that only something that you have learned since these investigations?—No, I think it is generally known that there is quite a good chance of the crack spreading beyond that hole.

If you had stopped a crack in that way with a located hole would it be recorded for a special examination from time to time?—That would depend on the size of the crack and where it was. There is a normal inspection procedure, and if it is considered a temporary repair there is a system which calls for a permanent repair within a given time.

Earlier, Mr. Abel had told Mr. L. G. Scarnan, Ministry of Transport and Civil Aviation, that after the Elba disaster a number of Comet aircraft were given proof tests of their pressure cabins. Six Comets were tested, of which one was Comet Yoke Yoke which subsequently crashed off Naples.

Mr. Scarnan: Is it right that all the aircraft that were tested passed the test satisfactorily?—Yes.

Would a fair inference from these tests be that the static strength of the pressure cabin was satisfactory?—I think so, yes.

Is it right that, before the exhaustive researches of the Farnborough report, it was generally thought in the industry that if the pressure cabin had a satisfactory static strength the danger of fatigue was not a very great one?—I think you would have to define what you meant by satisfactory static strength first.

If the pressure cabins were proof tested to a differential pressure of 11 lb. per square inch, was it generally thought that the danger of fatigue was not very great?—I believe that if you design for the ultimate strength of a factor of two or more it was then believed that the cabin would not be in danger.

Mr. Shaw then asked when did Mr. Abel first know of the manufacturing cracks in Yoke Peter and in other aircraft?

Mr. Abel: I personally did not know about them until after the Naples crash.

INSPECTION FOR CRACKS

Mr. Shaw: If you had known of them at an earlier date, say before Elba, would you have considered them minor repairs which could be left and not inspected?—I believe so, yes. That is, not inspected as a routine matter, and provided they were inspected to see that they had not propagated beyond the locating point.

When the chairman (Lord Cohen) remarked that he had understood a previous witness to say that he had not known there were manufacturing cracks, Mr. Shaw asked: How could anybody have inspected the cracks if they had not known they were there?

Mr. Abel: The whole area of the fuselage is inspected for cracks, and the inspector inspecting that area would in all probability notice there is a crack there and a locating hole at the end of it.

Mr. Shaw: Does that include taking off the reinforcing plates round the windows to see if there were any cracks beneath them?—No.

Mr. Abel said that the reinforcing plates would be covered by paint, but he would have thought it would have been possible to see the locating hole.

Mr. Shaw: The only possibility of them being detected on inspection would be if they had propagated since the paint was applied?—Yes.

Lord Cohen: So far as we know there is no record of the existence of these manufacturing cracks. If the inspector had noticed them, would he have made a record of them?

Mr. Abel: He would not have made a record unless the crack had gone beyond the locating hole. He would assume that proper authority had been received for the drilling of that hole.

Mr. Shaw: If you had known of these manufacturing cracks during the course of the investigations between the two crashes would it have disturbed you at all?

Mr. Abel: It is very hard to say. I doubt if it would—no. We might possibly have asked de Havillands about them.

Mr. Shaw concluded his questioning of Mr. Abel by asking: " Was metal fatigue in the pressurised cabin one of the matters you considered as a possible cause of the crashes? "

Mr. Abel replied: No, I don't believe it was.

Sir Hartley Shawcross, Q.C. (for the de Havilland company) asked Mr. Abel: Is this the first case where an aircraft has met with disaster for unknown reasons?

Mr. Abel: By no means.

Mr. Abel said the cracks they found in the course of various routine inspections of Comet aircraft fell into two categories. Some were cracks around the passenger door caused by mechanical damage, and some were caused by high-frequency pressure waves caused by the jet efflux.

Although the crack formation was somewhat different it was possible to get cracks arising in the fuselage from the effects of propellers. It was quite true to say that cracks developed during the life of aircraft other than the Comets, and they were well known in famous American makes.

B.O.A.C. had a prescribed routine for inspecting for possible development of such cracks and a similar routine for renewing certain parts of aircraft susceptible to fatigue. This again included other aircraft in general commercial service.

Sir Hartley asked Mr. Abel whether there might not be a very great difference between a crack which arose from a tensile fracture during manufacturing process and one which was set up by fatigue changes in the course of service.

Mr. Abel said he believed that there was that difference although he was not particularly an expert on fatigue. He did not think that a crack caused during manufacture, as Sir Hartley had described, would be anywhere near as dangerous as a fatigue crack.

He agreed with Sir Hartley when he suggested that a fatigue crack indicated the presence of a high stress on a particular part of the structure. The presence of the manufacturing crack did not indicate whether there was any stress on that part of the structure or not and he thought that such stress would have only been present during the manufacturing process.

Sir Hartley: You might think from the questions we have been having that this question of cracks is quite peculiar to the Comet, but it is not?—No.

Sir Hartley then referred to certain newspaper reports of yesterday's evidence in which it had been said that cracks were beginning to appear in the prototype wing which was under test at Farnborough at the same time as the Elba accident occurred. This was quite accurate but taken by itself it might be misleading.

He asked Mr. Abel whether or not it was a fact that the cracks in the prototype wing at Farnborough had appeared after what amounted to 6,700 hours of flying. Mr. Abel said he believed that to be so.

Sir Hartley: That was about double and in many cases more than double the life of any Comet aircraft in service?—That is correct.

Mr. Abel agreed that the crack found in the prototype wing was a fatigue crack which was not merely peculiar to the Comet.

He said that on the discovery of this crack on the prototype B.O.A.C. instituted a special inspection of Comets to see if any such cracks could be found in service aircraft. Included in these aircraft tested was the Comet Yoke Yoke which later crashed off Naples. It was subjected to a specially searching test.

Sir Hartley: Nothing was found to suggest any incipient fatigue either in the fuselage or in the wings?

Mr. Abel: That is correct.

Mr. Abel agreed that in spite of the fact that nothing was found a modification was introduced into the wings to give added strength at the place where weakness had developed after much longer flying in the prototype.

This modification was included in the Comet's certificate of airworthiness. Mr. Abel agreed that from his experience of both Comets and other aircraft there was no urgency to include this modification but they felt it preferable rather than doing repeated inspections in a difficult section of the aircraft to examine.

Mr. Abel said it had been a surprise to him to hear that there were manufacturing cracks in Comets.

Sir Hartley said that Dr. Walker had said that the cracks had nothing to do with the crash and Dr. Hall had said that if fatigue had occurred the cracks did no more then to accelerate it.

Just before Mr. Abel left the witness box Professor W. J. Duncan, one of the assessors, suggested that an answer about the importance of cracks might have been misleading.

" Would you agree with me," he said, " that any kind of crack whether arising from manufacturing or from fatigue might be important according to its location, its direction and of course its size? "

Mr. Abel: I would certainly agree with you there.

REDUX BONDING

Just before the inquiry adjourned, Mr. Eric Lewis Ripley, head of the Royal Aircraft Establishment accident investigation department, had been discussing with Sir Lionel Heald a theory advanced by Mr. Bruno Jablonsky of how the accident to Yoke Peter occurred.

Sir Lionel had said to Mr. Ripley that Mr. Jablonsky had been particularly interested in Redux adhesive used in the construction of the Comet. Mr. Ripley explained that it was used by the de Havilland company to secure the stringers to the skin both in the fuselage and the wings.

Sir Lionel: Are there any signs to be obtained from examination of the wreckage that failure of the Redux in any way contributed to the break-up of the Elba aeroplane when the pressure cabin gave way?

Mr. Ripley: I found no signs whatever in the wreckage which would suggest that the failure of the Redux contributed to the cause of this accident. In the centre of the fuselage area where we believe the primary failure took place the Redux joints are generally in very good condition indeed.

There were examples on the starboard wing of skin being torn away by a peeling action when the wing hit the sea. The Redux joining in the area of the pressure dome was in good condition and showed signs of having withstood considerable loading without failing at all.

He was present at Farnborough when Mr. Jablonsky was invited to draw attention to a typical failure of Redux upon which he could rely for this theory.

Mr. Ripley produced the piece in court and matched it with an adjacent piece from the wreckage, and showed the court scratch marks which continued on both pieces. This, he said, indicated that the scratch marks were made in the air and before the Redux failure had occurred after impact with water.

Sir Lionel: Is there any possibility of that fracture having taken place when the pressure cabin broke up at 30,000 ft.?—No. For the reason that it is associated with all the other damage in this rear fuselage area which is clearly water damage.

If the damage in this area had been caused by the release of pressure, then it would have been impossible to find evidence of pressure release in any other part of the aircraft. Evidence however had been found of such pressure release.

When Mr. Ripley was asked by Lord Cohen why it was impossible to have the release of pressure in two places, Mr. Ripley gave the analogy of the pricked balloon, saying " If you prick a balloon and then prick it again you can't have a second blow out."

The inquiry adjourned until Monday.

To be continued

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THE INSTITUTION OF MECHANICAL ENGINEERS

Summer Meeting, 1955

The Council of the Institution of Mechanical Engineers have accepted an invitation from the Chairman and Committee of the Southern Branch to hold their next year's Summer Meeting in Southampton and district. It is proposed that the Meeting should take place during the week beginning Monday, July 4.

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INSTITUTION OF PRODUCTION ENGINEERS

Opening of New Headquarters

The official opening of the new headquarters of the Institution of Production Engineers on October 28 was attended by more than 50 officers of local branches (chairmen, honorary secretaries, etc.). The degree of autonomy which the Institution permits its branches is, perhaps, the key to its growing strength and influence. This growing strength has resulted in the Institution having to seek larger premises for its headquarters no less than four times in 25 years. Sir Walter Puckey, who has been succeeded by Sir Leonard Lord as President, and who deputised for Sir Leonard in formally opening the new headquarters, indicated that the Institution were not blind to the fact that a further move might be necessary when membership increased again.

The new headquarters are at 10, Chesterfield-street, London, W.1, a house built about 1760 and now most tastefully and elegantly restored.

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VIKINGS WITHDRAWN FROM B.E.A. SERVICE

On Saturday, October 30, the last flight of the Viking air liners of British European Airways' fleet took place, from Northolt to London airport. It was also the last flight by a B.E.A. aircraft from Northolt airport, which will henceforth be used only by military aircraft. After eight years of Viking operation, the fleet has been withdrawn from service and is offered for sale.

BOOK REVIEWS

Formulas for Stress and Strain. By RAYMOND J. ROARK. Third edition. *McGraw-Hill Book Company, Incorporated*, 330 *West* 42*nd-street*, *New York* 36, *N.Y.*, *U.S.A.* (8·50 dols.); and *McGraw-Hill Publishing Company, Limited, McGraw-Hill House*, 95 *Farringdon-street*, *London*, *E.C.*4. (53*s.* 6*d.*)

The professional engineer rightly places a high value on a compact yet comprehensive summary of the formulæ and principles pertaining to the strength of materials, a source of reference that indicates limits within which a free judgment, based on experience, has to be used, and alternatives among which choice is to be made. The fact is that with the increase in size and complexity of machinery and structures generally, familiar problems, for which approximate solutions were formerly considered adequate, are now frequently found to require more precise treatment, and many less familiar problems, once of academic interest only, have become of great practical importance. Further, the solutions and data required are often found only in advanced treatises or scattered through an extensive literature, and the results are not always presented in a form that can be readily adapted to the requirements of the drawing office or laboratory. In this regard, Professor Roark's book is a noteworthy addition to the available works of reference on matters relating to stress and strain, as may be inferred from the review of the first edition which was published on page 9 of our issue for January 5, 1940.

In the present edition the aim of enlarging the scope and utility of the work as a source of reference for practising engineers has been effected in various ways. In the chapter on the flexure of straight and curved beams, for instance, the discussion of shear lag has been rewritten to bring in the results of recent investigations, and the table of formulæ for circular rings has been extended to cover the case of circular arches. Considerable revision has also been carried out in Chapter 12, where the tabulated data for the stress and deformation of pressure vessels now occupies nine pages, and the former example of stress calculation for thin vessels has been replaced by one that illustrates the use of improved formulæ and thus provides a means of comparison with experimental results. At other places the purpose of the revision has been to bring the subject into line with current specifications, as in the collection of formulæ for columns, which are particularised with respect to the kind of material, shape of cross-section, conditions at the ends, and the type of structure, whether building, bridge, or aircraft. Again, in Chapter 10, the table of stress and deflection coefficients for flat plates now contains a number of additional cases, and also the coefficients for slope at the edges; and a table of the coefficients for large deflections in the case of rectangular plates has been added. One feature which will be especially appreciated by research workers is the extensive bibliographies: two chapters together contain over one hundred references to original publications. Another is the detailed character of the information; the table of factors of stress concentration, although concisely arranged, covers twenty pages, and account has here been taken of the important work of Neuber.

There can never be complete agreement as to what such a book should contain. Perhaps more might have been said about the physical properties of concrete. However that may be, engineers and students alike will find a wealth of authentic information in Professor Roark's new volume. Few enjoy access to all the books which he has laid under contribution, and even fewer possess the skill and patience to discover, among so much dead wood, the growing points of engineering science.

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TRADE PUBLICATIONS

Copies of any of the following trade publications are obtainable from the addresses given, though distribution is sometimes restricted.

Aluminium for Electric Cables. ALUMINIUM UNION LTD., John Adam-street, London, W.C.2. The electrical, mechanical, thermal and chemical properties of aluminium. Methods of manufacturing and installing aluminium-sheathed cables; with service experience. Types, ratings and applications of aluminium conductors and methods of jointing. Miscellaneous types of cables and accessories, including those for high frequencies and aircraft. Descriptions of actual installations. Booklet with numerous illustrations.

Engine Fault Diagnosis. CRYPTON EQUIPMENT LTD., Bridgwater, Somerset. Location of faults in internal-combustion engines by systematic method of diagnosis, without dismantling; sequence of ten tests and list of instruments required; "Cryptoscope" plastic rotary-dial finger guide to test procedure; portable instruments and engine analysers. Illustrated booklet with sectional diagrams.

Light Alloy for Road Vehicles. NORTHERN ALUMINIUM CO., LTD., Banbury, Oxfordshire. Specialists in the production of aluminium sheet, bar and strip and in its applications. Booklet, fourth in series dealing with the design of road vehicles, entitled "Light Alloy Bodies for Road Haulage Vehicles." Details of the design and construction of three basic forms of tipping vehicles.

Woodworking Machinery. WADKIN LTD., Green Lane Works, Leicester. Machines for planing and moulding, tenoning, routing, all types of sawing, spindle moulding and pattern milling. Also three new machines, a cross-cut saw, a planer and jointer, and a belt sander. Illustrated folder giving details of 14 machines.

Electric Furnaces. BIRLEC LTD., Tyburn-road, Birmingham. New range of tool-room furnaces; vertical forced-air circulation furnaces for heat treatment up to 700 deg. C.; induction melting furnaces. Brochures giving technical details and operating results of actual installations.

V-Ropes and Pulleys. WILLIAMS AND WOMERSLEY LTD., Wakefield. Specialists in the production of endless V-rope drives. Booklet, giving data for the calculation of suitable drives and a rapid means of arriving at the size and number of ropes for standard motors up to 50 h.p.

Mobile Cranes. STEELS ENGINEERING PRODUCTS LTD., Crown Works, Sunderland. Specialists in the design of large mechanical handling equipment. Fourteen leaflets giving detailed specifications of lorry mounted, railway, mobile and rail cranes.

Chain Drives. RENOLD CHAINS LTD., Renold House, Wythenshawe, Manchester. Chain drives with an efficiency of 98·5 per cent. Range covers drives in 25 ratios for motors from fractional to 140 h.p. Pamphlet illustrating typical installations.

Acid-Resisting Cement. J. H. SANKEY AND SON, LTD., Ilford, Essex. Acid-resisting cement, chiefly used for bedding and jointing vitrified bricks and tiles for acid-resisting floors, walls and tanks. Pamphlet giving details.

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"PROCESS CONTROL"

Process Control is a recent addition to the list of journals which deal with specialised branches of technology. Its range, nevertheless, is wide, since its object is to inform the user of those instruments which are playing a growing part in increasing the efficiency of industrial operations. This theme is fully developed by Mr. A. J. Young in an article on "Instrument for Information," while Mr. H. K. Arkell outlines ways whereby instruments can help industry to achieve greater efficiency. Other contributions describe in more detail how process control is being applied to particular cases.

This journal is to be published monthly by the Colliery Guardian Company, Limited, 30 Furnival-street, London, E.C.4.

BOOKS RECEIVED

Some of the books noticed in the Books Received column are selected for extended review in later issues of ENGINEERING.

Uruguay. Overseas Economic Survey. By C. B. B. HEATHCOTE-SMITH. Published for the Board of Trade, Commercial Relations and Exports Department, by *H.M. Stationery Office*, *Kingsway*, *London*, *W.C.*2. (3*s.* 6*d.*)

This is the latest issue of the series of Overseas Economic Surveys, and covers economic and commercial conditions in Uruguay. The contents include transport and communications, currency and banking, government organisation, foreign trade, analysis of principal imports and exports, agricultural and mineral resources, production and industry, as well as labour, education and social legislation.

Graphics in Engineering and Science. By A. S. LEVENS. *John Wiley and Sons, Incorporated*, 440 *Fourth-avenue*, *New York* 16, *N.Y.*, *U.S.A.* (7 dols.); and *Chapman and Hall, Limited*, 37 *Essex-street*, *London W.C.*2. (56*s.*)

The object of this book is to help the student to gain a full appreciation of the graphic method of expression in analysing and solving problems. It is assumed that the student has a reasonable degree of proficiency in the use of drawing instruments, lettering, geometric constructions and line work. The book is divided into three parts covering fundamentals and applications of orthogonal projection, technical drawing practices, and graphical solutions and computations.

The Technical Report. Its Preparation, Processing, and Use in Industry and Government. Edited by B. H. WEIL. *Reinhold Publishing Corporation*, 330 *West* 42*nd-street*, *New York* 36, *N.Y.*, *U.S.A.* (12 dols.); and *Chapman and Hall, Limited*, 37 *Essex-street*, *London*, *W.C.*2. (96*s.*)

All phases of the technical report are fully treated in this book, whose contents include the fundamentals of editing, illustrating, duplicating, binding, distribution, security, filing and putting report files to work. The main aspects of writing are surveyed, with emphasis on successful procedures and on specific types of report—the progress report, the formal report, the market survey, the literature summary, etc.

The Economic Geology of the Fife Coalfields. Area III: Markinch, Dysart and Leven. By J. KNOX. Palæontology by F. W. ANDERSON. Department of Scientific and Industrial Research, Memoirs of the Geological Survey, Scotland. *H.M. Stationery Office*, *Kingsway*, *London*, *W.C.*2. (12*s.* 6*d.*)

This is the third and last memoir in the series on the Fife coalfields. An introduction describes the area and its physical features, and gives a summary of the geology. The rest of the book covers the types of rock in detail, and separate chapters are devoted to coal measures and superficial deposits. A glossary of mining terms, a bibliography, and an index complete the book.

Simplification in Practice. British Productivity Council Action Pamphlet No. 2. *British Productivity Council*, 21 *Tothill-street*, *London*, *S.W.*1. (1*s.*)

This booklet defines one of the lines of attack in the campaign to increase productivity in British industry, namely, the reduction of the number of types and variety of products made by a firm. It begins by listing ten reasons why simplification, as distinct from standardisation, is worthwhile. It then offers practical guidance on how simplification can be put into operation.

Table of the Gamma Function for Complex Arguments. U.S. National Bureau of Standards Applied Mathematics Series 34. *The Superintendent of Documents*, *U.S. Government Printing Office*, *Washington* 25, *D.C.*, *U.S.A.* (2 dols.)

This tabulation was prompted by specific needs in the fields of atomic and nuclear research. The results as presented will enable workers to catalogue the complex gamma functions in the set of known mathematical functions. The range, tabular interval of the arguments, and number of decimal places given have been chosen with regard to current usage.

Table of Sine and Cosine Integrals for Arguments from 10 to 100. U.S. National Bureau of Standards Applied Mathematics Series 32. *The Superintendent of Documents*, *U.S. Government Printing Office*, *Washington* 25, *D.C.*, *U.S.A.* (2·25 dols.)

This volume is a re-issue of a previous N.B.S. publication of the same title, known as Mathematical Table 13. In the new issue, the bibliography has been brought up to date, an auxiliary table giving the values of $p(1-p)/2$ replaces the table of values of $p(1-p)$, and another giving seven-place values of $E_2(p) = p(1-p^8)/6$ and $F_2(p) = q(1-q^8)/6$, where $p+q=1$, has been added.

NEW MATERIALS FOR THE ELECTRICAL ENGINEER*

By C. W. Oatley, M.A., M.SC.

Of recent years it has become known that electrical conduction can, under suitable circumstances, take place in non-metallic solids and the advent of transistors has shown that this phenomenon is likely to be of paramount importance in radio engineering. There are also a number of other practical devices which depend on non-metallic conductors.

CONDUCTION IN NON-METALLIC CRYSTALS

The atoms or ions inside a crystal are arranged in a regular lattice with a relatively immobile central nucleus and a number of electrons in motion round it. A metallic crystal is sometimes regarded as one in which the electrons are free to move through this lattice, whereas in a non-metallic crystal it is not possible for them to do so. In fact, if in both cases a straight line path is taken through the crystal there will be periodical variations of potential caused by the regular array of charged particles. If an electron has sufficient energy to surmount the highest "potential hill" it can travel freely along this path; this is the situation in a metal. In a non-metal the valence, or outermost, electrons have insufficient energy to surmount the potential hills and so each of them is confined in a valley. If, however, sufficient additional energy can be communicated to some of these electrons by an external agency they will be able to move through the lattice as freely as in a metal. Under these circumstances the non-metallic crystal may conduct electricity.

There is another way in which a non-metallic crystal can conduct, if some of its electrons have received sufficient energy from an external source to free them from their parent nuclei. An atom from which such an electron has escaped carries an excess positive charge and leaves what is known as a positive hole. An electron from an adjacent atom can readily move into this hole and by a repetition of the process the hole itself can move through the lattice carrying the excess positive charge with it. In many respects the positive hole behaves exactly like a free electron with a positive charge. In particular, it can conduct electricity.

No lattice structure is, however, perfect so that a free electron in its passage will from time to time encounter abnormally high potential hills, which it cannot cross, and will be deflected by them. In the absence of an external field it will therefore pursue a random, zig-zag path and even if an external field is applied, its motion will be largely random, although there will be a drift in the direction in which the field is urging it.

To produce free electrons and holes in a crystal it is necessary for excess energy to be communicated to the most loosely bound electrons so that they are detached from their parent nuclei. This may be done by raising the temperature of the crystal to a point where the thermal energy of the lattice is sufficient to release some of the electrons; swiftly moving particles such as electrons or α rays may be allowed to fall on the crystal; or the additional energy may be provided in the form of photons, or quanta, of radiant energy.

PRACTICAL APPLICATIONS

The effect of heat in increasing the number of free carriers and hence the conductivity of the material is made use of in the thermistors employed in many radio circuits. The properties of semi-conductors are employed in the wide range of asymmetrical and symmetrical non-linear conductors. The former includes selenium and copper oxide rectifiers as well as point-contact silicon and germanium diodes. They find a widespread use not only as straightforward rectifiers, but in modulators, mixers, detectors and in speech compressors and expanders. Typical of the symmetrical type are the non-ohmic silicon-carbide resistors, which are used in protective curcuits.

In many of these non-linear conductors the conditions are so complex that it is difficult to apply the theory of semi-conduction to them. On the other hand, in the recently introduced silicon and germanium junction diodes the composition of the material is most carefully controlled and the theory is understood in considerable detail.

Since the war, cells in which the active material is a layer of suitably treated lead sulphide, lead selenide or lead telluride have been developed and make detectors of radiation over a useful part of the infra-red spectrum one hundred times more sensitive than any other. The active layers in these cells are polycrystalline, and it seems certain that their action depends on effects taking place at the grain boundaries. These processes are closely allied to those operating in photo-voltaic cells and in the new type of television camera tube known as the Videcon.

PHOSPHORESCENT PHENOMENA

The zinc sulphide used on the screens employed in counting α particles has recently been activated by the addition of a small percentage of copper atoms. When an α particle strikes one of the active centres formed by the copper atoms as much as 80 per cent. of its incident energy is given back as light. As, however, in a typical screen there will be only one copper atom to 10,000 molecules of zinc sulphide there must be some highly efficient mechanism by which energy is transferred from the zinc sulphide lattice to the active centres. To explain this it must be assumed that the initial effect of the α particles is the production of free electrons and holes in the zinc sulphide lattice. These holes wander about until they meet copper atoms from which they capture electrons and become ionised without any direct encounter with an α particle. In due course the ionised copper atoms capture free electrons and return to their normal state with the emission of their characteristic green light. There is evidence to show that the excitation of the phosphors used in cathode ray tubes and fluorescent lamps by electrons and ultra-violet light respectively involves similar processes.

The delay which occurs in the decay of the trace on the long-persistence screens used in cathode ray tubes for radar and other applications cannot, however, be readily accounted for in this way. Furthermore, there is no reason to suppose that this mechanism is affected by moderate changes of temperature, although the rate of decay of the trace is highly temperature-sensitive. To explain this the existence of what is known as electron traps is postulated. These are irregularities due to impurities or other defects in the lattice, which may capture and immobilise the free electrons. If the attraction of the traps is very strong, electrons, once captured, can only be freed by the absorption of energy from radiation or swift particles. There may, however, also be shallow traps from which the electron can escape by acquiring energy from the thermal motion of the lattice. Now the acquisition of energy in this way is a random process so that if at a particular instant a number of electrons are held in shallow traps they will not subsequently all be released at the same moment.

The mechanism which is believed to be operative in long persistence phosphors is that when excitation by electron bombardment or by ultra-violet light occurs, free electrons and holes are produced, and the holes bring about ionisation of the activator centres. Some of the free electrons combine quickly with these ionised centres, thus causing the emission of a flash of light almost immediately after the original excitation of the phosphor. Other electrons are, however, trapped and these cannot re-combine with the ionised activator centres until they are released from the traps by the acquisition of thermal energy from the lattice. A considerable interval may elapse before this occurs, so that the emission of light from the phosphor decays gradually.

ELECTRON TRAPS

The existence of electron traps also explains why, if metallic electrodes are evaporated on to opposite sides of a non-metallic crystal and are connected to a battery and galvanometer, no appreciable current flows when the crystal is irradiated. In fact, the incident radiation usually only penetrates the crystal to a very small depth, and the electrons and holes formed in the region which is penetrated must travel across the rest of the region to the metal electrodes. If they become trapped in appreciable numbers they will set up a space charge which will completely neutralise the applied field and cause the flow of current to cease.

That this actually happens is shown by some experiments recently carried out in the Bell Telephone Laboratories in which a diamond was bombarded with a pulse of high energy electrons lasting only 5 microseconds; and the current flowing across the diamond round a separate circuit was measured during this interval for various values of the voltage across the crystal. The current was found to fall to a small fraction of its initial value in a few microseconds and the rate of decay was smaller the larger the voltage applied across the diamond since it would take longer to build up sufficient space charge to neutralise it.

The conditions are quite different if the crystal is in the form of a very thin slice so that the incident radiation can pass right through it without too much loss of energy. The conductivity produced in this way has been made the basis of operation of a picture storage tube known as the Graphechon.

ELECTRO-LUMINESCENCE

Mention may finally be made of a newcomer in which use is made of the phenomenon of electro-luminescence. Certain phosphors have been discovered which glow brightly when placed in an alternating electric field of a few tens of thousands of volts per centimetre. Very thin layers of the powders can be used so that such fields can be produced with only a few hundred volts, and as large areas can be employed the light output is sufficient to have many practical uses. It seems likely that this phenomenon is due to the fact that a few free electrons, produced by some other agency, are accelerated by the field until they have sufficient energy in their turn to generate still more free electrons so that the process is cumulative.

Summing up the present position with regard to non-metallic conduction it may be said that the basic phenomena are beginning to be well understood, but that in nearly every case of practical interest there are complicating effects which have not yet been fully elucidated. On the experimental side, impurities, even to the extent of less than one part in a million, can have an immense effect. When the problems of purification have been overcome the task of growing single crystals of the required materials and of introducing controlled amounts of known impurities into the lattice will remain. Finally, how to use the new materials in new practical devices will have to be learnt.

* Chairman's Address delivered to the Radio Section of the Institution of Electrical Engineers on Wednesday, October 13, 1954. Abridged. Mr. Oatley is in the Department of Engineering, University of Cambridge.

The Institution of Naval Architects' Autumn Meeting (continued from page 555)

SCALE EFFECT EXPERIMENTS ON SHIPS AND MODELS

SURFACE FRICTION EXTRAPOLATION

On several occasions, in the recent *Transactions* of the Institution of Naval Architects, reference has been made by Dr. Ir. W. P. A. van Lammeren, the Superintendent of the Dutch ship-model tank at Wageningen, to the 72-ft. model boat D. C. Endert Jr., a self-propelled "geosim" of a Victory ship, constructed for the purpose of investigating the scale effect between a full-size ship and its geometrically similar model.

The fourth paper in the programme of the Institution's recent Autumn Meeting at Torquay went into considerably fuller detail regarding this experimental work. It was entitled "Scale Effect Experiments on Victory Ships and Models" and was presented during the morning session on September 22, by Dr. Ir. van Lammeren and his co-authors, Dr. Ir. J. D. van Manen and Ir. A. J. W. Lap, who are also associated with the Wageningen tank. The chair was again occupied by Mr. R. B. Shepheard, C.B.E., B.Sc., Chairman of the Council of the Institution.

THRUST COMPARISONS

The authors prefaced their paper, which consisted largely of a very detailed series of tabulated results covering the comparative measurements of resistance and thrust on six geometrically similar models, ranging in scale from one-60th to one-18th of full size, and the D. C. Endert Jr., which is one-sixth the size of the actual ship, with a historical survey of previous work on scale effect, especially since 1930. The objections which might be raised to Froude's method of calculating a ship's resistance from model tests, they stated, were mainly that Froude's formulæ did not agree with Reynolds's Law, and that it was open to doubt whether the method of approximating the frictional resistance of a hull form by reference to that of an equivalent plate was permissible for practical purposes; it might be necessary to introduce into the formulæ for hull forms, in addition to the Reynolds number, one or more parameters which were characteristic for the particular ship form. In 1947, the American Towing Tank Conference introduced the Schoenherr Mean Line as a general-purpose extrapolator, but the question still remained whether, if it were used on ship forms, other quantities (and, if so, which) would play a part; and whether, in fact, the Schoenherr line for smooth plates was the "minimum turbulent friction line."

The results of the investigations recorded in the paper were that, so far as they had gone, the resistance tests with the family of Victory models and the model boat D. C. Endert Jr. had not given any clear indication of the correctness of any particular method of extrapolation; that the Schoenherr line was somewhat too flat, so that the prediction for the model boat became higher as the model taken as a starting point became smaller; that, at the most plausible values of the Hughes and the Lap-Troost form factors, both of those methods gave too steep an extrapolator; that the tests with the larger paraffin Victory models had been influenced, though only to a small extent, by tank-wall effect; and that the use of a thrust extrapolator offered no advantages beyond the use of a resistance extrapolator.

DISCUSSION

Dr. R. W. L. Gawn, O.B.E., who opened the discussion, thought that the main interest in the paper would centre on the bearing of the results on the skin-friction formulation. The broad upshot was that a reasonably close prediction of the measured resistance of the boat was obtained by each of the three skin-friction formulations considered by the authors from the results of tests of models of the size more usual in experiment tanks, namely, about 16 ft. to 20 ft. long, subject to a rather arbitrary form factor being accepted for two of the formulations. Predictions for the shortest model from the Schoenherr line were about 3 per cent. in excess, but about the same as for the larger models, according to predictions from Hughes and from Lap and Troost. In other words, the gradient by Schoenherr was a little too shallow for the wide range of models and for the other two formulations a little too steep, but the latter was avoided if the arbitrary form factor were accepted. The differences were not really marked and, he thought, did not appear of first importance.

At a meeting in August of the International Towing Tank Conference, it was decided to seek an agreement on a formulation for practical purposes on or before the next Conference. The aim was to obtain a formulation which would stand the test of a long period of time, as that of Froude had done. Much effort was being directed towards the determination of a true physical formulation, but it seemed that such a final solution was hardly yet in sight. Mr. W. C. S. Wigley's remarks on the previous day had a bearing on that. He worked back to Navier's unsolved equations of 1830 for a viscous fluid, and until they were solved it was very doubtful whether the true physical formulations would be found. The investigations described in the paper would provide valuable guidance in that search, though it would still be necessary to check the import of the Froude and other formulations which the authors had not considered in their paper.

NEED FOR TOWING TRIALS OF LONG FAST SHIPS

Curiously enough, many of the formulations that had been proposed showed a fair margin of agreement for the skin-friction resistance of long fast ships, concerning which reliable information was almost absent, whereas there were small but strange differences over the model range, despite the abundance of results at that end of the scale. The tests of the model boat afforded a good steady point beyond the model range, but the real requirement was firm information on the resistance of actual ships. It was not a new problem; it was emphasised in the famous report of the British Association for the Advancement of Science as long ago as 1867, but the only real response had been the old tests of the Greyhound and the recent tests of the Lucy Ashton. The results for the latter were accurate and reliable; but she was a short ship. The Victory ship was about 2½ times as long, and he suggested that the authors should consider including the measurement of the towing resistance of a Victory ship in their future programme. Such a trial would be difficult and expensive, otherwise it would have been carried out long before, but it was vital and he did not think it possible to do without it.

The alternative approach through shaft thrust measurements had certain limitations, and that was brought out from the thrust measurements on the model boat in the paper. One surprising feature of those results was the decline in thrust deduction factor with the roughened surface, which was contrary to the results given in the speaker's 1942 paper, on roughened hull surfaces, presented to the North-East Coast Institution. A few models were tested at Haslar with roughened surface, and the broad upshot of the tests was that the thrust deduction factor appeared to be nearly the same as with the smooth surface. There was a very real advance in the approach to the determination of wall effect on resistance through images. The method was ingenious and he was relieved that the authors concluded that the wall effect was really negligible, even for the largest model. Would the authors indicate the wall effect deduced from the approximate blockage formula? It would be helpful if the air resistance for fore and aft motion were expressed in coefficient form, to facilitate comparison with other classes of ships, and if the percentage additional resistance due to air could be given.

PNEUMATIC HULL-ROUGHNESS TESTER

Professor G. Aertssen said that the work described represented an important step towards the establishment of an extrapolator for ship-model correlation, and gave valuable information on the minimum turbulent friction line nearly as far as log. R = 7·8. An extrapolator must be established on small models and, in the authors' view, a smooth model boat. For log. R = 7·8, the Prandtl-Schlichting diagram required a limiting grain size of 0·020 mm., or 800 micro-inches for the hydraulically smooth model, and the authors, after careful treatment of the submerged portions of the boat, expected the model to be smooth. Several times during recent months, roughness measurements on ships had been undertaken in Belgium. The hull roughness was measured by means of a pneumatic tester used in connection with a Solex instrument, with which it was possible to take nearly 1,000 measurements in a day. The smoothest ship investigated had a Nikuradse number of nearly 0·050 mm., or 2,000 micro-inches, while the best sample plate had a Nikuradse number of 0·026 mm., or nearly 1,000 micro-inches. Although the sample plates, painted simultaneously with the ship with anti-corrosive and anti-fouling paint, were smoother than the ship, his own opinion was that a hull surface finished with the care described by the authors could not have a grain size of more than 0·020 mm. or 800 micro-inches, even after due allowance was made for structural roughness. Roughness measurements taken, for example, by means of a Talysurf instrument, would give a better description of the surface than a pneumatic tester, but it was difficult to translate them into hydraulic terms, and, furthermore, the samples were not the ship. Boundary-layer measurements were taken by means of a Pitot tube. Those measurements certainly must give information on the smoothness of the hull, and he was somewhat surprised not to hear more about them.

THE EQUIVALENT PLANK

Professor E. V. Telfer said that the paper showed how far away they were at times, in discussions among experts, from the view of the subject which William Froude took so many years ago. The authors had said, in their introduction with regard to William Froude's classic method, that "It is open to doubt whether the approximation of the frictional resistance of a hull form by means of that of the equivalent plate is permissible for practical purposes." They used the term "equivalent plate." He had the impression that he introduced the term "equivalent plank" into the subject in his 1922 paper before the North-East Coast Institution. Naval architects did not seem to be at all clear about what was meant by the Froude "equivalent plank." Froude himself said that a ship form extrapolated in exactly the same way as a plank having the length and the area of the ship model; that had been the fundamental statement of the problem. It was not clear whether Froude himself ever applied that fundamental principle; but, Dr. Telfer submitted, the fundamental principle still stood, and ship forms would extrapolate in exactly the same manner as a plank having the same length and surface. In short, Froude said that

the slope of the extrapolator must be changed in accordance with the length/breadth ratio of the model.

In 1927, Dr. Telfer continued, he gave a method of combining the Froude and the Reynolds laws which really included the Froude case, and one of the terms he introduced then was "extrapolator." No one had used the word before for that particular purpose, and he called it *the* extrapolator, as something which applied to the ship form, and might be used to predict the ship values. He protested against any reference to a Hughes, Schoenherr or other extrapolation in connection with the problem, and suggested to the authors that, if they would use either his own or Dr. Hughes's work to calculate the true equivalent length/breadth ratio for their Victory ship models, they would find that there was no better extrapolator than that of the simple equivalent plank; and that went right back to Froude's original concept. The authors were emphatic, in their first paper, that the Schoenherr line was too flat. That was quite true, and it also disposed of anything they might find within the application of the Prandtl-Schlichting line, because that line differed by only 0·0001 from the Schoenherr. Therefore, the extrapolation of the Prandtl-Schlichting line must be identical with that by the Schoenherr line, and if the Schoenherr was dismissed, the Prandtl-Schlichting line also should be dismissed.

THRUST DEDUCTION SCALE EFFECT

The curse of the Schoenherr line was that it allowed experimenters to deceive themselves. The difficulties of experimenting were two-fold. In the first place, with small models the trouble was to get rid of laminar flow. When they came to wall effect, the Schoenherr line, by coming above the true extrapolator, apparently deluded them into thinking that they had no such effect. If the Schoenherr line accurately allowed for laminar flow and wall effect, there would be no objection, but obviously it could not allow for those differences. They must be able to say that there was no such thing as wall effect and laminar flow on models. If there had been time to re-present the authors' work, it could be seen how severely the experiments suffered from laminar flow right up to 16 knots. He felt that a major problem before experimenters was the accurate determination of the turbulence resistance and the elimination of laminar flow from the results. Unfortunately, the authors had not succeeded in eliminating laminar flow, and he thought that they based too much hope on the mere act of putting a 1 mm. wire round the models to establish laminar flow. They would have to adopt many different methods of inducing laminar flow and proving that it had been eliminated.

The authors had done excellent work in the investigation of thrust-deduction scale effect. They had found—to their surprise, he thought—that the thrust deduction increased with the size of model. What he thought was happening in their work was that, with the curious reaction-type rudder on the larger models, thrust deduction appeared to be increasing because the resistance of the rudder was climbing up a transition line, whereas, for the smaller models, there was only a small rudder resistance. Rudder resistance must not be allowed to confuse knowledge of thrust deduction, and he was sure that the authors would expand their work to find out just what the rudder resistance was in each case, and would separate out the results from the total thrust deduction.

JET ENGINES TO ELIMINATE PROPELLER-RACE EFFECT IN TOWING

Dr. S. Livingston Smith, C.B.E., said that the authors' work on the 72-ft. model boat was the nearest to the Lucy Ashton experiments. He asked whether any wake and rudder effects from the towing vessel affected the towed vessel, and whether any experiments were carried out to ascertain that the towed vessel was or was not affected. He had suggested the use of jet engines in the B.S.R.A. experiments because doubts were expressed whether they could tow a vessel satisfactorily and obtain accurate measurements of resistance. He knew that the jet engines could give a perfectly constant thrust. Did the authors find a variation in the towing pull during the trials on the model boat? As Dr. Gawn had remarked, the 72-ft. model boat was a long way from the ship. The B.S.R.A. did their experiments on a 200-ft. ship. Did the authors intend to carry their work further, and tow by some means a full-size vessel?

Dr. J. F. Allan emphasised that it was absolutely essential to attain high accuracy to be able to draw useful conclusions from the results. He was a little uneasy about the method of towing the model boat, and would like to know how the speed was determined when they towed the boat on a long line. Was it determined from measured distances on the shore, or by a Pitot method, or by other means? The results in the paper had great value in relation to the question of surface friction and extrapolation. The conclusions arrived at were very interesting, namely, that the indications were that the Schoenherr line was too flat, and that the Lap and Hughes methods gave good agreement, using suitable form factors. The question of the study of surface-friction extrapolation might appear to have been given an unnecessary amount of attention, but it was very important to determine the true extrapolation if only from the point of view of determining the performance of an absolutely smooth ship. If it was as determined by the Lap and Hughes extrapolation methods, a considerable reduction of power could be effected on existing ships by achieving greater smoothness.

He thought that the question of form factor was a true approach to the subject, but it would be very difficult to settle. They were determined to obtain a practical decision on a method which could be agreed on internationally, at the earliest possible date. In their appendix, the authors indicated further work which was done with models down to a very small scale, and there appeared to be an interesting general picture of agreement; but there were clear indications of laminar flow on the smaller models, and he agreed with a previous speaker that the use of very small models was dangerous, and likely to lead to trouble. It would be very interesting if full-scale tests could be made on the Victory ships. If that was the ultimate intention, he would strongly recommend the use of the jet-engine method, as employed on the Lucy Ashton.

LAMINAR FLOW AND SMALL MODELS

Mr. H. Lackenby, M.Sc., observed that ship-model correlation had been carried out by three methods, namely, the Schoenherr, the Lap-Troost method (which included a form correction), and the Hughes method (also including a form factor). On several occasions, he had been accused of favouring the Schoenherr method, and he wished to correct that impression. He suggested, however, that the authors might have been a little unfair to Schoenherr. The Schoenherr form factor appeared only to be a skin-friction formulation for smooth surfaces. He was rather surprised that the wall effect was so small, because in the Lucy Ashton tests they made a correction which was criticised for being on the small side. He agreed with Dr. Allan that it might be dangerous to draw too many conclusions from the use of small models, because there was the problem of laminar flow, which might well re-establish itself after the turbulence stimulator. Another bogey when experimenting with very small models running at very low speed was laminar separation. On the question of how thrust deductions were reduced with increasing resistance of the hull, he suggested that it might be caused by constant suction on the ship.

AUTHOR'S REPLY

Professor van Lammeren, replying to the discussion, thanked the Council of the Institution for the opportunity to present the paper on the special occasion of the unveiling of the memorial to William Froude. One point raised was that the Schoenherr curve seemed to be too flat and that the Hughes extrapolator was too steep. Dr. Gawn asked if they could agree with that. They could; but they must be practical and consider what was the result for the actual ship when using the Schoenherr line or the other extrapolators. Every model basin had to build up its own system. He could produce 50 or perhaps 100 results of ship trials and service operation which showed that the allowances which resulted from applying the Froude method were not so bad. In future, when they decided to use a certain line, they would have to build up a system for making allowances.

They had been asked whether we were going to extend the tests to the actual ship. They hoped to do so—it had always been in the programme—by towing the actual ship in the Red Sea; but first they must carry out other tests, such as measuring the wake distribution behind the ship with the turning of the propeller. Dr. Gawn was surprised that the thrust deduction fraction declined with the roughness of the surface. That was obvious, because, with the smooth model, there was a higher loading of the propeller. It might be due also to the fact that the circumferential inequality of the wake was less with the rough model than with the smooth model; so that for the ship it might be less. Professor Aertssen referred to the roughness of the model boat, but the model boat was not very rough. If the Schoenherr or other extrapolator were applied, there was a difference of 3 per cent., which was not very much for the model boat. However, if it did appear that the model boat was too rough, they could repeat some of the tests with a smoother surface.

ROTATIONAL OR DOUBLE MODELS

Professor Telfer referred to the "equivalent plate" expression and suggested using a plate having the same length as for the model. But what about the boundary layer? The thickness of the boundary layer on the plate would be quite different from that on the model. It would be better, instead of using such a plate, to use rotational or double models. (Professor Telfer: "I referred to the equivalent rectangular plank.") It would still be better to use double or even rotational models. They had not analysed all the results by using all the various methods, because of lack of time; that was one reason why the results were given in tabulated form, so that anybody who wished could do that work on his own behalf.

As to the doubt expressed concerning laminar flow on the small models, they had repeated the tests many times and obtained good consistency in the results. He was not sure whether they got laminar flow on all the models. It was a very good suggestion to repeat some of the tests without rudder, and he hoped to be able to do that. Dr. Livingston Smith mentioned propeller-race effects on the resistance of the model boat. The distance between the boat and the towing boat was 170 m., and the race of the propeller was not in the centre. He was certain that the propeller did not influence the model boat. For measuring speed they used Pitot tubes, and the measurement apparatus was calibrated on the measured mile. The tests were repeated many times, always with the same results. In reply to Dr. Allan: They had carried out tests on two actual ships, measuring the speed, etc., for various conditions, and were to test another Victory ship to measure the thrust, wake distribution and, if possible, the resistance. Mr. Lackenby had expressed surprise that the wall effect was much smaller than in the case of the Lucy Ashton. One of the reasons might be that the Lucy Ashton was running in shallower water and at greater speed.

To be continued

LABORATORIES OF THE ELECTRICAL RESEARCH ASSOCIATION

PLANS FOR THE LEATHERHEAD PREMISES

The history of the British Electrical and Allied Industries Research Association is one of continuous development, as well as of much useful work on numerous subjects in many branches of the science. Of recent years the problem of providing accommodation in which the necessary investigations can be carried on has therefore not unnaturally become pressing, but it is satisfactory to be able to record that a solution will soon be reached, which, though perhaps only temporary, will do something to meet the most urgent requirements.

HISTORICAL BACKGROUND

It may be recalled that the Association was founded, as the Electrical Research Committee, in 1917, and was incorporated three years later. To begin with work was carried out at the National Physical Laboratory, the universities, the technical colleges and on the premises of the member organisations, but in 1935 a laboratory was opened at Perivale. During the 1939–45 war it became clear that further accommodation would be required and, as this could not easily be obtained at Perivale, the Council acquired a site of 48 acres at Leatherhead.

In parenthesis it may be remarked that Leatherhead has become quite a research centre owing to the presence both of the British Electricity Authority's Research Laboratory and the Electrical Development Association's testing station. The British Coal Utilisation, the Food and the Printing, Packaging and Allied Research Associations are also established in the neighbourhood.

A BUILDING SCHEME

In May, 1944, Mr. H. J. Rowse, F.R.I.B.A., was instructed to prepare a building scheme to cover the great majority of the Association's activities and shortly afterwards the offices were moved to Thorncroft Manor, Leatherhead. The implementation of the architect's first scheme, which was estimated to cost about £1,000,000 was, however, delayed by the introduction of the Electricity Bill; and it was also decided to defer the construction of the high power building and to retain Thorncroft Manor as offices. Later, the scheme was further modified and it was arranged, at an estimated cost of £400,000, to construct high voltage and workshop buildings, but to restrict the general laboratory accommodation to researches, which were essentially inter-dependent. The result was to provide for between two-thirds and three-quarters of the work previously carried on at Perivale with room for limited expansion. Research on rural electrification will continue to be carried out at Shinfield and on wind power at the Aeronautical College, Cranfield.

To finance this scheme £100,000 was set aside from the Association's reserve, while an appeal for capital contributions was made, which has so far brought in £197,000. When another £3,000 has been obtained, the Department of Scientific and Industrial Research will make a capital grant of the remaining cost up to £100,000.

A contract for what may be regarded as the first part of the work was awarded to Gee, Walker and Slater, Limited in December, 1953; and it is hoped that the new buildings will be ready for occupation in the spring of 1956. They will comprise a main block containing interchangeable laboratory units as well as a library, photographic department and office accommodation. There will also be high voltage and workshop buildings.

MAIN LABORATORY

The main laboratory will be on three floors with an additional floor of smaller area. The ground, second and third floors, will be of normal height, while the first floor will be 18 ft. high to allow of work needing greater headroom. One third of its total area will, however, be occupied by a gallery and mezzanine floor to give additional space, and an observation platform. The central section of the building will contain the offices, library, photographic department and drawing office, while in the wings there will be a total of 15 laboratories, each with an area of 50 ft. by 35 ft.

Since it draws largely on special power supplies and on precision measurements the work on cables and heavy conductors will be carried out on the ground floor. The unit devoted to this purpose will contain a cable trench for investigations on long conductors, floor ducts for interconnections, large test objects and non-portable measuring gear. There will also be access to an open paved testing space. The adjacent generating room will contain the main battery and alternating and direct-current supplies for the whole building, while in the nearby standardising laboratory will be high precision equipment and the central instrument stores.

Although high power short-circuit investigations will still be carried out at Perivale, the application of light current and electronic techniques to heavy electrical equipment, with some electrochemical work, will be conducted in the new building. Small scale investigations on the electric arc, work on medium voltage dielectrics and researches on fuses will also be accommodated.

PROPERTIES OF MATERIALS

Three laboratories on the first and second floors of the main building will be devoted to research into the properties of materials, particularly insulation. One of these will be equipped with alternating and direct-current supplies up to 100 kV and up to 25 kV at higher frequencies. Ignition and radio interference problems will be dealt with in a laboratory on the second floor. This will include equipment for observing transient phenomena in short electric sparks at the highest speeds, ignition both in hazardous atmospheres and in internal combustion engines and interference with radio telecommunication equipment. The study of methods of heating under controlled conditions will be conducted in a ground-floor laboratory in which one or more experimental heat pumps will be installed, as well as facilities for laboratory-scale work on thermal storage, water heaters and airing cabinets. Two laboratories will be devoted to surge and transformer researches.

HIGH-VOLTAGE LABORATORIES

The separate high-voltage building will comprise a central hall with an area of 100 ft. by 50 ft. and 50 ft. high. This will be flanked by a transformer laboratory and generator, instrument and dark rooms. The central hall will contain a tank so that tests can be made under oil.

The building will be able to house a 3,000-kV surge generator; a 1,000-kV 50-cycle test transformer; a high-current surge generator; and high-voltage direct-current equipment. It will therefore be possible to extend the range and type of the Association's high-voltage work and to overcome the limitations imposed by conditions at Perivale.

The workshop will be a single-storey building and will comprise a main machine and other shops, in which it will be possible to construct and modify the wide range of test equipment used in the laboratory.

ELECTRIC HEATING INSTALLATION

The main building will be heated by electric immersion heaters with hot-water storage feeding conventional radiators through a low-pressure two-pipe system. The heat will be controlled by thermostats and a time switch. Owing to the main hall of the high-voltage building being 50 ft. high with most of the equipment concentrated in the lower part, floor heating will be adopted, cables threaded into ducts bedded in the floor being employed. Thermocouples and heat meters will allow the performance of this installation to be studied. The workshop building will generally be heated in the same way, but in the part that is temporarily to be employed as a canteen portable thermal storage heaters will be used. Thermocouples and heat meters will be installed to study both systems and experiments will be made on methods of controlling the storage heaters, so as to take into account both the off-peak supply conditions and the short periods of daily use.

Among the factors which determined the adoption of this tri-partite system of heating was the saving that could be obtained by balancing the heavy day-time load against a night heating load to give a high load factor. In addition, it will enable three forms of electric off-peak heating to be studied, to obtain continuous records of their performance under controlled conditions and to correlate these with the characteristics of the heated building.

ELECTRICITY SUPPLY

The main electricity supply for the new buildings will be obtained at 11 kV through duplicate feeders from the South Eastern Electricity Board. It will be stepped down to 415 volts in three 500-kVA transformers and will be distributed to a switchboard in the basement of the main building. This board will be connected to sub-boards in each wing, which will also be fed from the generator room. From these sub-boards distribution will, in turn, be made through rising mains to a board in each laboratory. From these laboratory boards a 240-volt single-phase ring main in wall trunking at sill level will supply socket outlets at frequent intervals. In addition, there will be a plug board for linking any one of the special supplies to a number of socket outlets. Provision will also be made for three-phase supplies to certain points and for local generators or auto-transformers to feed the plug-board circuits.

In the high-voltage building the incoming mains will terminate at a main switchboard in the transformer laboratory to which special supplies from the generator room in the main building will also be brought. Distribution thence will be on similar lines to that in the main building. In the transformer laboratory there will be additional points for 100-ampere three-phase four-wire supplies. The installation in the workshops building will be on conventional lines, although flexibility will be achieved by the use of overhead distribution trunking.

Off-peak electric space heating will be, as has been mentioned, a feature of the installation. This will cause the major load to occur outside the normal working hours in the heating season. The principal switchboard in each building will therefore carry a separate switch or circuit-breaker for controlling the heating supplies, while in the main building there will be a separate heating distribution board on which the contactors and thermostatic control relays associated with the thermal storage heater batteries will be mounted.

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INSULATED ELECTRODE HOLDER

The Lincoln Electric Company, Limited, Welwyn Garden City, Hertfordshire, are now marketing in this country the Lincoln-Jackson holder for welding electrodes. This is a heavy-duty tool which retains the electrode in the jaws by a coil spring enclosed in a cup. Four sections of insulation are arranged to cover the jaws and handle, and the connecting cable passes up through the insulated handle. It is claimed that there is complete protection against accidental arcing. All parts are replaceable.

THE SECANT APPROXIMATION AND THE PERRY FORMULA

EXPRESSIONS FOR ECCENTRICALLY-LOADED STRUTS

By R. G. Pearson, B.A., B.C.E.*

In 1953, Jackson, Rosenhead and Murphy[1] published an article discussing Webb's approximation to sec θ which had the general form

$$\sec\theta \approx \frac{\pi^2 + A\theta^2}{\pi^2 - 4\theta^2} = F \text{ (say)} \quad . \quad (1)$$

where A is a constant. Webb gave A = 1·04 but, as his derivation is unknown, the article referred to was an attempt to check his value by the method of least squares. A value of A = 1·0260 was obtained by minimising the integrated square of the proportional errors, i.e., by determining the value of A which made

$$\int_0^{\frac{\pi}{2}} \left\{\frac{F - \sec\theta}{\sec\theta}\right\}^2 d\theta \quad . \quad . \quad (2)$$

a minimum. The integration was carried out numerically using Simpson's formula applied over intervals of $\theta = \frac{1}{50}\frac{\pi}{2}$.

This evaluation of the constant interested the author as he had been using A = 1·048 in an extended series of tests on timber columns. The latter value of A had been obtained by writing the approximate equation in the form

$$(\pi^2 - 4\theta^2)\sec\theta = A\theta^2 + \pi^2 \quad . \quad (3)$$

and determining A by the standard method for calculating a regression coefficient. The range of θ considered was 0 to 1·55 radians with intervals of 0·05 radians.

The difference between the two least-squares values led the author to consider more precise means of calculating A. As a result of a suggestion by Dr. E. J. Williams of the Division of Mathematical Statistics, Commonwealth Scientific and Industrial Research Organisation, the integrated square of the proportional errors (given above) was minimised and solved mathematically in terms of sine and cosine integrals to give

$$A = \frac{\text{Si}\,\pi + 0{\cdot}25(\gamma + \log_e 2\pi - \text{Ci}\,2\pi - \pi\,\text{Si}\,2\pi) - \frac{4}{\pi}}{1 + 0{\cdot}25\,\pi\,\text{Si}\,2\pi - 0{\cdot}75(\gamma + \log_e 2\pi - \text{Ci}\,2\pi)},$$

where

$$\text{Si}\,x = \int_0^x \frac{\sin t}{t}\,dt,$$

$$\gamma + \log_e x - \text{Ci}\,x = \int_0^x \frac{1 - \cos t}{t}\,dt,$$

and

$$\gamma = 0{\cdot}577216.$$

These integrals have been tabulated[2] and substitution leads to A = 1·0407. Hence Webb's value of 1·04 is precise for the range $0 < \theta < \frac{\pi}{2}$.

The accompanying graph shows the percentage proportional errors in the approximation for several values of A from zero to 1·093 $\left(= \frac{16}{\pi} - 4\right)$, the latter giving zero error at both $\theta = 0$ and $\theta = \frac{\pi}{2}$.

The graph shows clearly that A = 1·00 gives a convenient approximation precise enough for most practical purposes, particularly for incorporation in a working-stress formula, and the approximation with this value of A was recommended many years ago by Hawken[3, 4], apparently independently of Webb. Hawken derived it by considering the relation between the lateral deflections of eccentrically-loaded initially-straight columns and of centrally-loaded initially-curved columns. Using the approximation

$$\sec\frac{\pi}{2}\sqrt{\frac{p}{p_e}} \approx \frac{1 + 0{\cdot}25\frac{p}{p_e}}{1 - \frac{p}{p_e}},$$

the secant formula for eccentrically loaded columns,

$$p = p_1 \Big/ \left\{1 + \frac{e\,a}{k^2}\sec\frac{\pi}{2}\sqrt{\frac{p}{p_e}}\right\}, \quad . \quad . \quad . \quad (4)$$

where p = column load per unit area,
p_1 = extreme fibre stress on the concave surface,
p_e = buckling stress,
e = eccentricity of load,
k = least radius of gyration of column cross-section,
and a = distance from neutral axis to the extreme fibre,

may be solved to give

$$p = \frac{\left[p_1 + p_e\left(1 + \frac{e\,a}{k^2}\right) - \sqrt{\left\{p_1 + p_e\left(1 + \frac{e\,a}{k^2}\right)\right\}^2 - 4\,p_1 p_e\left(1 - \frac{e\,a}{4\,k^2}\right)}\right]}{2\left(1 - \frac{e\,a}{4\,k^2}\right)} \quad . \quad . \quad . \quad (5)$$

The approximation accordingly renders the secant formula explicit and so removes a major objection to its use in design.

The author has found the secant formula (slightly modified to allow for the nature of his column material—timber) very satisfactory for estimating the maximum loads of laboratory test columns,[5] and the adoption of a value A = 1·05 or even higher may be warranted for such purposes.

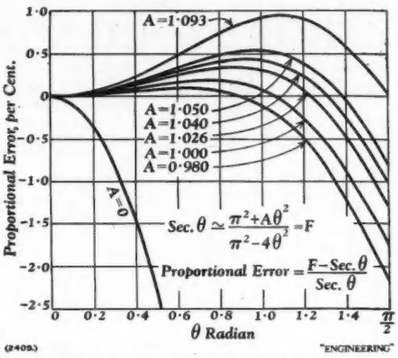
It is of interest to consider the approximation with A = 0. Sec $\frac{\pi}{2}\sqrt{\frac{p}{p_e}}$ becomes $\frac{1}{1 - \frac{p}{p_e}}$ with the proportional errors increasing steeply from zero for $p = 0$ to $-21\frac{1}{2}$ per cent. for $p = p_e$. The secant formula with this approximation reduces to

$$p = \tfrac{1}{2}\left[p_1 + p_e\left(1 + \frac{e\,a}{k^2}\right) - \sqrt{\left\{p_1 + p_e\left(1 + \frac{e\,a}{k^2}\right)\right\}^2 - 4\,p_1 p_e}\right]. \quad . \quad . \quad . \quad (6)$$

This is similar to the well-known formula for initially curved columns, except that e replaces c, the maximum amplitude of the initial curvature. Because of the difficulty of handling the secant formula, equation (6) is often applied to eccentrically loaded columns with the eccentricity replaced by an equivalent curvature $1{\cdot}2e$, in which form it is commonly known as the Perry formula. This procedure is the same as using the secant formula with sec $\frac{\pi}{2}\sqrt{\frac{p}{p_e}}$ replaced by $\frac{1{\cdot}2}{1 - \frac{p}{p_e}}$, an approximation with proportional errors of + 20 per cent. at $p = 0$, + 5 per cent. at $p = 0{\cdot}75\,p_e$, and $-5\frac{1}{2}$ per cent. at $p = p_e$. As the secant approximation forms only part of the Perry formula, however, the error in the column load given by that formula will always be less than any error in the approximation. The general expression for the proportional error in the average compressive stress given by the Perry formula for eccentrically loaded columns may be readily obtained by differentiation of equation (4); thus,

$$\frac{dp}{p} = -\left(1 - \frac{p}{p_1}\right)\frac{d\sec\theta}{\sec\theta}.$$

Hence, if the secant term is overestimated, as it normally will be in practice, the Perry formula will underestimate the column load. The closer the average stress p is to the extreme-fibre stress p_1, that is, the smaller the bending stress, the smaller is its proportional error. The Perry formula might thus be expected to be satisfactory for columns of moderate eccentricity. For large eccentricities, greater accuracy would be obtained if the factor 1·2 were reduced. However, Webb's approximation leads to the secant formula being more accurate and no more trouble to use than the Perry formula, so the main justification of the latter as a design formula for eccentrically loaded columns is no longer valid. Bleich[6] has pointed out a theoretical inadequacy of the assumptions on which the secant formula is based, but formulæ superior theoretically do not appear readily adaptable to practical use without a considerable increase in complexity.



Proportional errors of some approximations to sec θ. For practical purposes, in a working-stress formula for columns, it is convenient and sufficient to make the constant A equal to unity; for timber, a value of 1·05 has been found satisfactory.

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DEMONSTRATION APPARATUS FOR STRUCTURAL PROBLEMS

VISUAL AID FOR MOMENT DISTRIBUTION CALCULATIONS

By R. J. Wilkins, M.SC.(ENG.), A.M.I.C.E., M.I.STRUCT.E.*

In the present-day treatment of the theory and design of structures in steel, light alloy and reinforced concrete, one very marked difference is apparent compared with the methods of earlier years. There is, in many modern methods of construction, a willingness both to design and erect frames which depend for their structural action upon continuity at the joints of the various beams and columns making up the frame. Two factors contribute to this: firstly, the ease with which monolithic joints can be produced at a site by a suitable design of shuttering and steel rods in the case of reinforced concrete, or of welding or riveting in the case of steelwork. Secondly, the modern methods of structural analysis (largely based upon such methods as moment distribution) are well within the capacity of most structural designers. Such methods can be carried out to any degree of accuracy which may be desired and as justified by the particular problem.

In teaching these methods at the universities and technical colleges, the need is often felt for a simple portable set of apparatus from which structural frames can be built as required so that the elastic deformations of a structure can be made visible to a class while the lecture develops and theoretical analysis is proceeding. To meet this need the apparatus illustrated in Fig. 1 has been designed and constructed and, since it is essentially simple to construct and within the capacity of any small workshop, details are given in order that its use may be extended if it should be considered to be of service to others.

Most distribution processes depend upon following some sign convention consistently throughout the work; it little matters what the convention is, but it is necessary to acquire familiarity with the particular shape or direction of rotation upon which it is based. The need for a "visual aid" is most marked in this connection to explain the conventions which have been adopted.

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Referring to Fig. 1, a reasonably heavy base member *a* (in the case of the existing apparatus, a rolled-steel channel) is provided with slotted holes to take either "hinged" feet *b* or "fixed" feet *c*, which are interchangeable as required and fastened by knurled nuts from below. The elastic strips *e* representing the members of the structural frame are inserted in the slots of *b* or *c* according to the end conditions it is intended to represent. The corner joints *d* are made from suitable lengths of light-alloy rod slotted at right angles on a milling machine and provided with a central hole, as indicated in Fig. 2. A large number of joints are easily and economically made in this way. The flexible strips *e* are of Perspex or similar elastic material capable of large displacements, though many kinds of strip are now easily obtained and equally suitable. A sufficient number of strips and joints are now available with the existing apparatus to enable any particular kind of frame to be made as required.

The light-alloy tube *f* carries two adjustable pulleys *g* so that horizontal loads can be applied by means of the loaded hangers and the effects of lateral movements studied. The vertical loads are applied to the structural model by slotted clamps, hangers and weights. Fig. 1 clearly shows the simple nature of the construction, the ease of manufacture and the wide variety of possibilities of the apparatus.

It should be mentioned that some variation of thickness is to be expected from many of the elastic materials used for the strips, and that consequently the fit of the strip inside the slotted joints may vary, but this is easily overcome during the assembly of a building frame or portal by the use of paper shims at the joint. The apparatus should be regarded more as a visual demonstration model rather than as a means of obtaining experimental results to compare with those obtained by theoretical analysis, as in order to obtain large movements which can be easily seen, the elastic model is obviously subject to eccentricities and moments not present in the real structure where movements are small compared with dimensions. At the same time, the apparatus has given measured "sway" forces which approximate closely to those obtained by calculation. The forces applied at the horizontal hangers to restore the members to the vertical are assessed by reference to plumb lines hanging from the upper joints.

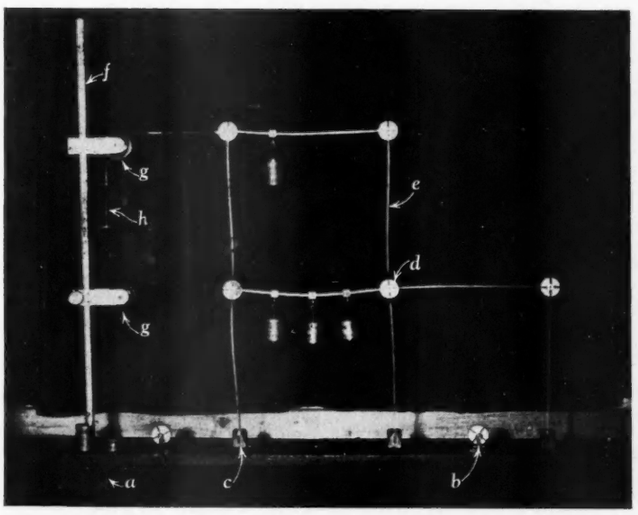

Fig 1 Moment distribution calculations depend on following a sign convention consistently through the problem; a visual aid such as this model greatly assists students to grasp the essentials of the process.

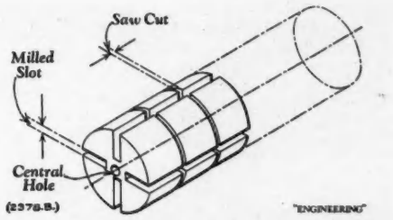

Fig. 2 The corner joints, used to give continuity between adjacent beams and columns, are easily machined from light-alloy rod.

The apparatus has been used, with success, to assist appreciation of the following topics during lectures and also to clear up particular difficulties in the structures laboratory where it is available to assist discussion at all times :

(1) Illustration of a sign convention.

(2) Demonstration of the effect of "hinged" or "fixed" feet upon the structural action of a portal.

(3) Tracing the effect of continuity on the variation of tension from top to bottom of a proposed reinforced-concrete beam.

(4) Illustration of the presence, direction and magnitude of "sway" forces in the structural analysis of a problem by moment distribution methods.

(5) Discussion of the effect of horizontal and vertical loads in a continuous structure.

(6) Demonstration of the dispersion of an effect through a frame, so showing that while adjacent spans may be appreciably affected, those at a distance may be safely neglected in calculations.

Although other features of the apparatus may develop, such as the use of curved members, the present article will have served its purpose if it introduces to a wider circle an easily constructed and, in both senses, very flexible demonstration apparatus. The existing set was designed by the author and made in the workshops of the Departments of Civil and Mechanical Engineering, University College, London.

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COMPETITION FOR STUDENTS AND APPRENTICES

With the object of encouraging craftsmanship and draughtsmanship in the scientific-instrument industry, a competition for apprentices and learners of either sex is held each year in connection with the Physical Society's exhibition of instruments and apparatus. Competitors must be under 22 years of age on March 31 next and entries will be accepted from the employees of firms, research associations and institutions which have exhibited at the Physical Society's annual exhibition at least once during the last three years, from employees in the workshops or drawing offices of educational establishments, from students attending recognised workshop or machine-drawing courses at technical colleges and schools, and from other selected bodies. The classes under which work may be offered are: scientific instruments and components, tools and gauges, optical components and systems, blown-glass and silica ware, sections of instruments and scale models, and draughtsmanship. Further particulars may be obtained from the Secretary, The Physical Society, 1 Lowther-gardens, Prince Consort-road, London, S.W.7.

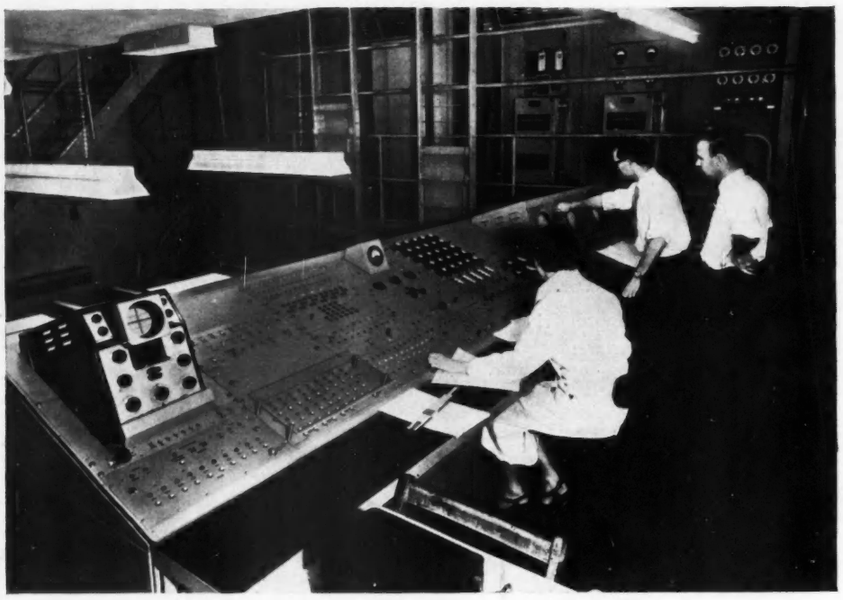

Fig. 1 Main control panel of Tridac. Tridac can be set to perform a calculation at a rate equivalent to the flight speed of the aircraft which it represents. Real components of the aircraft can then be included in the computer circuit.

THREE-DIMENSIONAL ANALOGUE COMPUTER

PREDICTING HIGH-SPEED FLIGHT

To solve many of the problems associated with high-speed flight, projectiles, radar and guided missiles, an analogue computing machine occupying 6,000 sq. ft. of floor space has been built at the Royal Aircraft Establishment, Farnborough, Hampshire. Known as "Tridac" (Three-Dimensional Analogue Computer), it is the largest calculating machine so far built in this country and was designed jointly by the R.A.E. and by Elliott Brothers (London), Limited, Lewisham, London, S.E.13, who were also responsible for its construction. A general view of the installation appears in Fig. 2 and Figs. 1 and 3 show respectively the main control panel and the control room.

WORKING MODEL

Unlike the more common digital computer, which merely performs a series of mathematical operations in sequence, the analogue machine serves in effect as a working model in three dimensions of the aircraft or missile under examination, the motion of which it simulates in terms of a system employing both electronic and hydraulic elements. The main functional difference, therefore, between Tridac, which can complete several tasks simultaneously—or very nearly so—and a digital computer lies in speed of working; a problem can in many cases be solved several hundred times more quickly by the analogue than by the digital system. This comparison applies, of course, only to existing computers and to the actual computing time; the period required for setting-up the computer and preparing programmes for it is not included.

Tridac has been designed to supply test data concerning, for example, a guided missile, without subjecting the missile itself to test, and many stages in the development of a new design can thus be completed before a prototype model is actually constructed. Known characteristics of the missile are set up in the computer, which then determines its flight path under given conditions; automatic plotting tables and a three-dimensional viewer included in the installation enable the real motion to be visualised.

Allowance can be made in the computer for such effects as changing aircraft trim due to consumption of fuel and variation of aerodynamic drag with height; quantities such as speeds, distances and altitudes are represented by voltages and shaft angles in accordance with predetermined scales, and such mathematical operations as resolution and integration are performed electronically.

ELECTRONIC "BRICK" UNITS

The basic analogue quantity in Tridac is a direct-current voltage and the basic element in the majority of the computing units is a high-gain direct-current amplifier with input and feedback impedances arranged to give an overall transfer function, corresponding, for example, to addition or integration. To avoid errors due to drift in the amplifiers, each amplifier is stabilised by association with a separate drift-stabilising alternating-current amplifier of either the mechanical-chopper or magnetic-modulator type. The gain of the basic direct-current amplifier is of the order of 60,000 and the drift stabilisers can confine the drift to within a few millivolts.

To facilitate servicing, all the amplifiers and similar units approximately 12 in. by 8 in. by 3·5 in. in size, are built in "brick" form, on small chassis, which slide into arrays of pigeon holes in the cabinets. There are 44 cabinets containing in all about 2,000 bricks, of which approximately 600 are direct-current amplifiers, 350 are mechanical-chopper stabilisers, and 250 are magnetic-modulator stabilisers. These and other electronic bricks, dealing with such operations as multiplication, division, resolution and curve generation, can be interconnected in any required system by plug-and-socket boards.

HYDRAULIC SERVO-UNITS AND POTENTIOMETERS

In order to achieve the required speed of response, a group of nine electrically controlled hydraulic servo-motors have been incorporated in the computer and are known as "synthetic gimbals" Each unit is provided with its own 35-h.p. electric motor and pump delivering oil at 2,000 lb. per square in chto the main hydraul c valves; a common low-pressure pump supplies oil at 250 lb. per square inch to pilot valve . The servo-motors drive sets of potentiometer , of which there are about 224, directly or throug i sine or cosine linkages; and they may be used t multiply voltages appearing in the main elec-tronic computation by the appropriate servo input or by the sine or cosine of the appropriate servo-shaft angle. Many of them are employe i in "axis transformation" calculations, in whic i the motion of an aircraft about axes through its centre of gravity is represented by corresponding motions of several servo-motor shafts.

Plant housed in a central generator room supplies power at various voltage levels and frequencies to the entire simulator, which under peak conditions absorbs approximately 650 kW from the mains. The voltages are accurately stabilised in separate voltage-stabilising bricks before they are applied to the computing units, and these units are subject to a constant check by a monitoring system which detects and gives warning of any fault conditions that may arise. The total number of valves employed in the computer is 8,000 and a comprehensive air-cooling network is provided to prevent over-heating.

REAL COMPONENTS INCLUDED IN COMPUTER CIRCUIT

The analogue computer is particularly useful when set to operate on a real or unity time scale; its speed of calculation is then equal to the rate at which the corresponding real events would occur in practice. Not only does this enable the motion to be studied realistically, but actual components of the aircraft or missile can be included in the computer circuit and their effect on its motion investigated. An aileron motor or automatic pilot may be tested in this way and records made of their characteristics.

It is possible to include in the computer circuit not only the instruments and control mechanisms of the aircraft under examination but also the pilot. He is provided with "displays" of radar and instrument information supplied by Tridac and operates controls of the normal pattern, which drive potentiometers giving sets of voltages to be fed back into the computer. Tridac is thus able to take account of human response to signals, and to indicate the effect of a pilot's speed of reaction on an aircraft's flight.

Before Tridac can begin a calculation considerable information must be supplied to it. In the case of quantities which do not change as the problem proceeds, such as the size of an aeroplane wing, or the relation between rudder deflection and rudder-bar movement, there are a large number of potentiometers to be set; 2,000 are available for this purpose. For known variations—the change in the speed of sound with height for example—specially-shaped cams and potentiometers are provided, and adjustable electronic devices incorporating sets of biased triodes are employed for other non-linear variations.

SOLVING FLIGHT PROBLEMS

The way in which Tridac works may be illustrated by the following examples. Suppose that the forward speed of an aircraft is represented by a voltage on a scale of one volt equals ten miles per hour. This voltage, and many others, can be shown on meters, and the speed of the aeroplane can therefore be observed continuously; recording instruments enable a permanent record of the information to be taken when required. The voltage representing forward speed may be fed into an electronic integrator, which produces a second voltage representing the distance covered by the aeroplane, again according to some pre-arranged scale which might be, say, one volt equals 100 miles. This voltage also appears on a meter.

Alternatively, the voltage denoting forward speed might be fed into a "resolver" into which is also set, either by hand or automatically, the

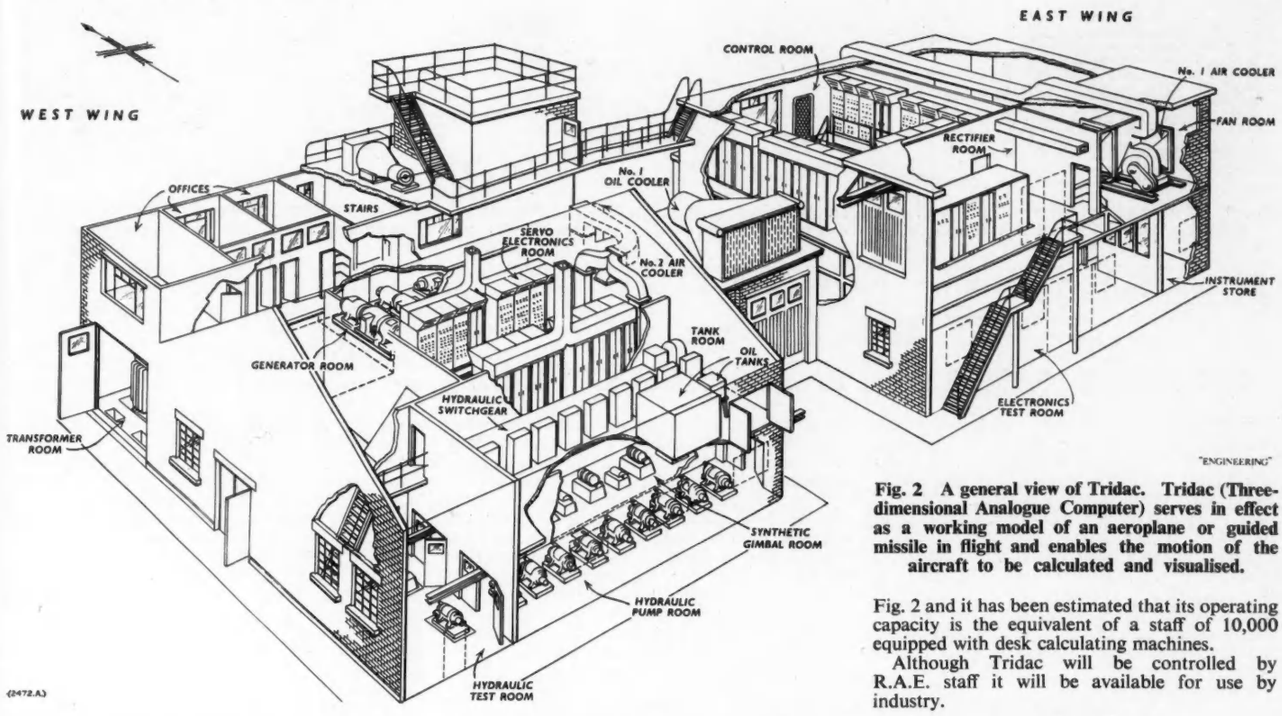

Fig. 2 A general view of Tridac. Tridac (Three-dimensional Analogue Computer) serves in effect as a working model of an aeroplane or guided missile in flight and enables the motion of the aircraft to be calculated and visualised.

direction in which the aeroplane is flying, say, for example, 20 deg. north of east. The resolver then issues two more voltages, one representing the rate at which the aeroplane is moving eastward, and the other the rate northward. These two voltages can be fed into two integrators which give output voltages representing distances covered by the aeroplane in the easterly and northerly directions, and these voltages, observed on meters, enable the position of the aeroplane to be plotted on a map.

AUTOMATIC PLOTTING TABLES

Usually, however, events move too rapidly for manual plotting and an automatic plotting table is provided. This is a flat board on which runs a carriage moving east and west; the carriage incorporates a long rail, pointing north and south and carrying a pen which marks a sheet of paper laid on the board. The carriage is moved by the "eastings" voltage so that it travels towards the east by an amount representing the eastward travel of the aeroplane according to a scale of, for example, ten miles to the inch; at the same time the pen is travelling along the rail under the influence of the "northings" voltage. The pen, therefore, moves simultaneously east and north, and traces a representative path of the aeroplane on the paper. With a more complicated resolver the variations in height of the aircraft may also be taken into account, by feeding into it angles of climb and dive; another plotting table can then be used to give a continuous record of aircraft height.

Although the speed of the aircraft may vary considerably, Tridac can still perform the desired calculations, and can, moreover, estimate the speed from values of engine thrust, which are themselves derived from throttle settings and engine characteristics. These are set into the computer by means of a series of knobs. Changes in direction can be calculated from the settings of control surfaces and allowance is made for such varying quantities as height, speed and trim.

It is also possible to simulate an action between a bomber and a pursuing fighter, thus, for example, illustrating the speed of response of the fighter to the bomber's evasive action. The motion can be stopped and repeated as often as the operator wishes and the effectiveness of different aircraft as interceptors can be investigated. Each aircraft would then be represented in the computer by data corresponding to its aero-dynamic characteristics. Similar calculations can be performed for guided-missile operations, including beam-riding, homing and command-link systems.

By simulating the motion in three dimensions of real aircraft, Tridac provides an economic means of solving flight problems; it is therefore the tool of the aerodynamicist and engineer rather than the mathematician. For practical investigations in this field accuracies within 1 per cent. are normally sufficient, since errors in data are often of that order; Tridac, which gives an error of less than 0·1 per cent. of full scale in each operation, can therefore in general fulfil this requirement.

AVAILABLE TO INDUSTRY

The construction of Tridac was started in January, 1950, and, although it is now complete in most major respects, a period of trial operation will be necessary before any large-scale research can be undertaken with its aid. It has been installed by the Ministry of Supply at a total cost, over the five years of building, of £750,000. Its size may be gathered from the drawing Fig. 2 and it has been estimated that its operating capacity is the equivalent of a staff of 10,000 equipped with desk calculating machines.

Although Tridac will be controlled by R.A.E. staff it will be available for use by industry.

AGWAC

A computer similar to Tridac in function and operation is being installed at the Long Range Weapons Establishment, Salisbury, South Australia, and has been designed jointly by the Ministry of Supply, the Department of Supply, Australia, and Elliott Brothers (London) Limited; it has also been constructed by Elliott Brothers. Known as "Agwac" (Australian Guided Weapons Analogue Computer), it is to be used in the solution of problems concerning the flight and control of aircraft and missiles acting against moving targets, and can operate on a real time scale and a slow-motion 10 : 1 scale. Calculations are performed by means of standard electronic plug-in brick units and electro-mechanical servo-motors, and the installation includes a maintenance console and a small differential analyser for solving two simultaneous second-order differential equations. To enable it to work efficiently under the conditions encountered on the Salisbury site, Agwac incorporates a closed-circuit air-cooling system employing refrigeration plant. This cooling equipment was designed and built by Eaton-Williams (Millbank), Ltd., and Woods of Colchester, Ltd.

Fig. 3 Tridac control room. The action of the computer involves both electronic units and hydraulic servo-motors. Three-dimensional viewers and automatic plotting tables enable the flight path of an aircraft to be visualised.

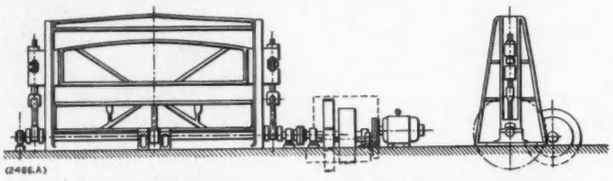

Fig. 1 A corrugating press of the traditional type. It is simple and relatively cheap to install and operate, but has a low output rate.

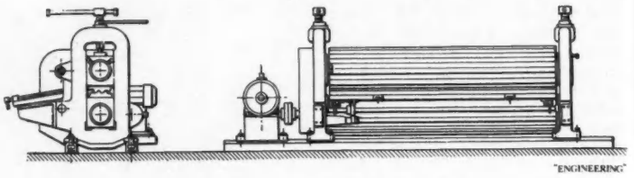

Fig. 2 The rotary corrugating machine is faster in operation than the press, and can accommodate two sets of dies on one pair of rolls.

FORMING CORRUGATED SHEET BY ROLLING

HIGH-SPEED PRODUCTION IN A MULTI-STAND MILL

The simple corrugated sheet, with wave-form corrugations, has been produced for many years. The earliest method of production was press-corrugation. For this purpose a special corrugating press (Fig. 1) was employed. It had a wide table and a vertically-reciprocating head working in slides which would accommodate dies designed to form up to three corrugations at each stroke. The press was simple, cheap to install and maintain, and the tool costs were low. Re-tooling for a different set of corrugations could be carried out quickly. Large numbers of these presses were built and many are still in service.

One disadvantage of this type of corrugating machine is its low rate of production, and the next development was the rotary corrugating machine (Fig. 2), which consists of a pair of parallel rolls grooved longitudinally. Both rolls are power-driven, and the sheets are fed in sideways manually. The grooves are often machined in six cast-iron or steel segments, which are secured to hexagonal shafts and can thus be changed easily. Adjustment is provided to ensure accurate meshing of the rolls, and to allow for sheets of varying thicknesses. As a rule the circumferences of the rolls are large enough to carry grooved segments for two different sets of corrugations. The machine then includes a feed table which is synchronised with the roll drive to ensure that each sheet enters the correct set of corrugating grooves. The tooling costs are greater on this type of machine than on the older press, but the increased cost is offset by the greater production which is possible on the rotary machine. Both the press and the rotary machine have the advantages of versatility, relatively low cost and small size, and are likely to continue in use where these qualities are important.

In recent years, however, there have been two developments which have brought about the need for new methods of corrugating. In the first place, high-speed production of sheets by the wide-strip process has made it necessary to adopt corrugating methods which can keep pace with strip production. Secondly, several new troughed sections have been introduced in place of the traditional wave-form corrugation, with the object of obtaining a better weight-to-strength ratio. Some of these new sections cannot be produced by the old methods.

Progressive forming by passing the material through a series of rolls arranged in tandem, each pair of rolls taking the forming process a little further until it is completed at the last stand, has been practised for a number of years on narrow strip. Continuous forming of tubes ready for welding is an obvious example. Machines of this type are readily adaptable to the production of forms other than the closed sections required for tubes, and they are widely used for rolling sections of many different kinds. Until recently this method of cold-forming has been restricted, in the main, to narrow strip work. In America it has been applied successfully to wide strip and sheet, and machines of this type are now made in Britain.

ROLL-FORMING OF WIDE MATERIAL

A machine for cold-forming wide material consists of a number of roll stands, as in Fig. 3, each housing a pair of rolls mounted vertically one above the other. The rolls stands are arranged in tandem, and the contours of the rolls are such that as the material passes from the entry end of the machine to the delivery end it is gradually and progressively rolled from the flat to the finished form in which it is required. The machine is, in fact, basically the same as that used for narrow strip, but it is modified in detail to suit the wider material.

In all roll-forming processes the designer is faced with the necessity for producing the required finished section accurately with the minimum number of forming stages; he has also to take into consideration such questions as avoiding too severe a deformation at any of the stages, which would cause rapid roll wear, and allowing for variation in quality and gauge of the material being worked. The selection of the most satisfactory forming speed will depend upon the shape of the section and the thickness and other characteristics of the material.

As a general rule a linear pass speed through the machine of 40 ft. to 120 ft. per minute will be chosen, although in a fully-integrated system speeds of 300 ft. to 400 ft. per minute may be possible when dealing with light gauges and highly-ductile material. Unless the machine has been designed for a specific purpose, or for a very small range of sections and materials, it is essential to provide an adequate range of speed variation. It is also necessary to make provision for "inching" material through the machine, as this has to be done when proving newly-developed roll forms.

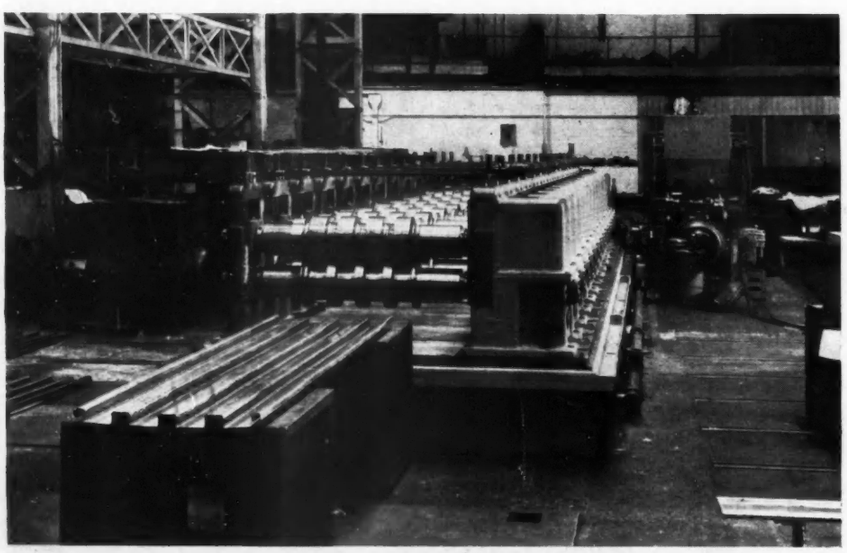

Fig. 3 The high-speed 14-stand roll-type corrugating machine shown here can form 4,000 12-ft. long sheets in an eight-hour shift. It will produce sheets with trough corrugations, which have a better strength-weight ratio than traditional corrugated sheets.

FORMING-ROLL DESIGN

Each complete roll form is usually built up on a shaft as a number of rings bored to suit the shaft diameter, so that the form can be expanded or contracted laterally by the insertion or removal of spacers or shims. This provides adjustment for variation in the gauge of the sheet being worked, and also allows for correcting any slight inaccuracies which might occur in the final section forms.

The rolls may be of cast iron, heat-treated Meehanite, through-hardened or case-hardened alloy steel, the choice being influenced by the required roll life, initial cost in relation to the output required from the rolls, and the amount of modification which it may be necessary to make in the proving stage. In some special cases, where very soft material is being worked, and where it is particularly important to avoid surface abrasion, it may be desirable to make some of the components of the roll assemblies in lignum vitæ or some other non-abrasive material such as Tufnol.

A LARGE SHEET-FORMING MACHINE

What is claimed to be the heaviest machine for roll-forming wide material so far built in this country has now been completed by Joshua Bigwood and Son, Limited, Wolverhampton. It is designed to handle sheet up to a maximum width of 42 in. before forming and a maximum thickness of 14 s.w.g. (0·080 in.). A production rate of the order of 4,000 12-ft. sheets per 8-hour shift has been allowed for in the design. The machine is illustrated in Fig. 3, and the principal data are set out in the Table.

There are 14 forming stands. Each stand has a pair of rolls, a gearbox containing worm and wormwheel reduction gears, and toggle-mounted spur-gear drive to the top and bottom roll

shafts which gives a wide range of roll-centre adjustment. The roll shafts are carried in adjustable chocks. Each complete assembly is mounted on a sub-baseplate, so that the stand can be lifted out of the line if necessary, either to reduce the number of forming stages or for overhaul. The drive is transmitted from stand to stand by chain-type flexible couplings.

TABLE I—*Dimensions and Capacity of* 14*-stand Corrugating Machine for Wide Material*

Number of forming stands	14
Maximum width of material before forming	42 in.
Maximum thickness of material	14 s.w.g.
Pump motor rating	75 b.h.p.
Pump motor speed	1,420 r.p.m.
Hydraulic motor rating	60 b.h.p.
Hydraulic motor speed range	250/1,250 r.p.m.
Maximum roll shaft centres	12 in.
Vertical adjustment of top roll shafts	5½ in.
Diameter of roll shafts	4 in.
Overall length of forming machine	32 ft.
Overall width of forming machine	8 ft. 6 in.
Overall length of hydraulic drive	6 ft. 9 in.
Overall width of hydraulic drive	4 ft. 6 in.

All the stand components are machined in jigs and finished to close limits to ensure interchangeability. The roll shafts are of sufficient length to deal with sheets having a developed length of 42 in. They are machined from alloy-steel forgings, chromium plated after machining in order to preserve the original close fits in the roll bores, and to prevent scoring of the shaft surfaces during roll changing. Each set of roll components is secured by lock nuts on the end of the roll shaft, adjacent to the inner side of the outer housing. The shaft journals in the outer housing run in small-clearance needle and roller bearings housed in sleeves, so that the bearings are not disturbed when the outer housing is withdrawn for roll changing. The upper roll shaft is adjustable vertically by screws with lock nuts, micrometer ring scales being provided for fine setting.

Machined facings are provided on the housings so that brackets carrying vertical-spindle rollers or slipper-type guides can be fitted when required. The baseplate is of fabricated steel construction, and is sectionalised in standard lengths to facilitate shipment and erection. Coolant is distributed by drip-pipes disposed over each roll stand.

HYDRAULIC DRIVE

The machine is driven by a hydraulic motor rated at 60 b.h.p., taking its hydraulic fluid from a pump driven by a 75-b.h.p. alternating-current motor running at 1,420 r.p.m. This type of drive was chosen because its output torque adjusts itself automatically to the requirements of the machine at inching, threading and normal production speeds. It is extremely flexible and the speed can be controlled smoothly from a scarcely-perceptible movement to the maximum by means of a hand-wheel operated large-capacity control valve. By running the machine at a very slow speed it is possible to observe the deformation of the sheet at each forming stage. The hydraulic drive has proved very successful in operation, but provision has been made in the design for the use of a constant-speed motor and a multi-speed gearbox, or variable-speed alternating-current or direct-current motors, if desired.

Necessary accessories for a roll-forming machine are suitable guides at the entry and delivery ends. In the case of the former, the simplest arrangement provides for the entry of the sheared sheet or strip by hand over a fabricated table fitted with long adjustable side guides. At the delivery end it may be necessary to provide guides to prevent the twisting or curving of the section as it leaves the machine, and when dealing with sections formed from cut-to-length sheets, arrangements for piling, either by hand or by mechanical means, will be needed. Where sections are formed from material which is fed from a coil into the forming rolls a suitable coil-box or coil-holder must be provided, complete with a roller leveller if necessary. At the delivery end of the machine a flying shear, saw, or rotary cutter is needed, according to the section being produced.

AUTOMATIC TRAIN ANNOUNCEMENT

New Train-operated System at Stratford

A new system of automatic announcement, which is operated by the trains themselves, has been developed by the General Electric Company, Limited, Kingsway, London, W.C.2, to the specification of the Signal and Telecommunications Engineer, Eastern Region, British Railways, and has been installed at Stratford, Essex. "Train approaching" and "train standing" messages are recorded on one of 25 tracks on a continuous loop of magnetic tape 3 in. wide. The appropriate message is then selected in the signal box and is stored until the train itself operates a track circuit at the approach to the station. This causes a "play-back" head to be moved automatically to the pre-selected track on the tape, thus setting the latter in motion and connecting it through a reproducer and amplifier to the platform loud-speaker, which announces: "The train now approaching No. . . . platform will call at . . ." As the train passes into the platform track it operates a delay relay, so that after the doors of the train have opened the loud-speakers announce: "The train standing at No. . . . platform will call at . . ." The "approaching" announcement can be automatically cut out at peak periods.

The announcements are pre-selected by push buttons on the panel shown below. Up to four can be made and stored in each platform group, a lamp being illuminated to indicate the number of each. When the announcement for a train is stated a red lamp is illuminated next to the respective storage indication and both lamps are extinguished when the train leaves the platform. Traffic, such as goods trains, for which no announcement is necessary, but which occupies the platform track circuit, are included in the selection by operating a "no announcement" key. In the event of an alteration, or incorrect selection, the stored selections can be cancelled and fresh ones made. The announcements can be checked by a monitor loud-speaker and emergency statements can be made through a microphone to any of the platforms.

CONTROL APPARATUS

The control apparatus associated with this system consists of Post Office type telephone relays and uniselectors. The selected announcements are stored by positioning a uniselector on the appropriate bank contact. Information regarding approaching trains, which is provided by the track circuits and describer equipment, is subsequently connected to these selection storage switches by a further uniselector, known as the sequence switch, and the "start" signals are transmitted to the reproducer equipment. If the track conditions indicate that there is insufficient time available for broadcasting the "train approaching" announcement, the "start" signal for that recording is not transmitted.

REPRODUCTION ARRANGEMENTS

As regards reproduction, on the receipt of a "start" signal from the control apparatus, a uniselector is rotated and stops at the marked bank contact, thus placing the reproducing head on the required track of the tape. The tape motor is then started and the high-tension circuits associated with the reproducer are completed through the relays, so that the announcement is broadcast. The ends of the tape are joined by a metal foil strip to form a loop and this strip completes the circuit of a "stop" relay, so that at the end of the announcement the reproducers and amplifiers are returned to a waiting position for the next "start" signal.

The tape is driven at a constant speed of 7·5 in. per second through gearing by a $\frac{1}{10}$-h.p. motor and after passing under the reproducing head and main capstan rollers falls into a container. The width of this container only slightly exceeds that of the tape, which is thus guided so as to form folds. This enables about 30 ft. of tape to be accommodated in a container 17 in. long by 7½ in. deep.

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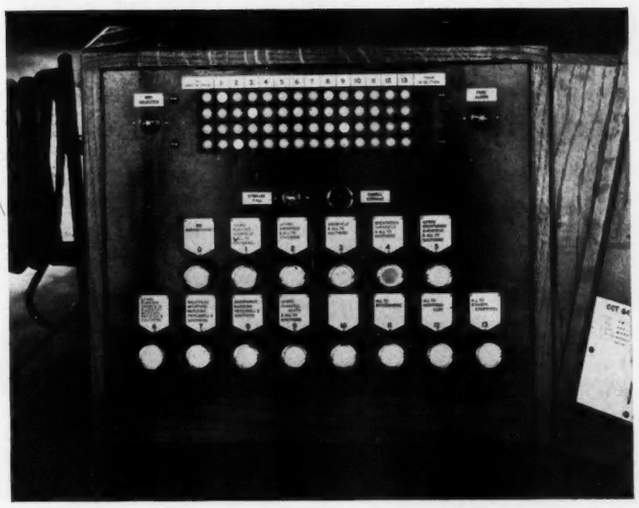
EXTENSIONS TO POWER-GAS CORPORATION'S SHOPS

The second-stage of development at the South Works of the Power-Gas Corporation Limited, and Ashmore, Benson, Pease and Company, of Stockton-on-Tees, has just been completed; the first stage was completed in 1951 when the Power-Gas Corporation celebrated their golden jubilee.

In the constructional shops two transverse bays, 85 ft. wide and 250 ft. long, have been added. Each bay is provided with a 10-ton and a 20-ton crane. The two longitudinal bays which are 65 ft. in width were originally 342 ft. long, and they have now been extended by 170 ft. As a result of this development the floor area has been increased by 50 per cent. to 215,600 sq. ft. The assembly area has been increased by 130 per cent. A new machine shop is 112 ft. wide (or 130 ft. if an annexe is included) and 250 ft. long, with provision for an extension to 700 ft. The shop has a floor area of 32,500 sq. ft., and the concrete floor has an oil- and dust-proof surface.

To cope with the increased quantities of materials, the stockyard gantry has been extended from 400 ft. to 800 ft. and a new 10-ton crane has been installed.



One of the push-button panels in Stratford signal box which is used in connection with the automatic train announcement system.

A NOVEL TEXTILE MECHANISM

AUTOMATIC CONTROL OF SLIVER WEIGHT

The textile industry was one of the first to be mechanised and former generations of textile machinery designers showed a keen appreciation of technical and mechanical requirements. Designs developed at an early date were adequate for many years, and in the worsted spinning trade it became traditional for manufacturers to buy new machinery only when they wished to expand production, or when their existing machinery was beyond repair. For some years now, however, new methods and new equipment have been in process of development, a process which is still going on.

The most recent addition to the range of new textile machinery is the Raper drawing system. It embodies a new mechanism, the Raper Autoleveller, which has been developed for the automatic control of the weight of worsted sliver. The Raper system introduces principles which are entirely new to the worsted spinning trade and makes it possible to reduce the number of operations required to produce the yarn. The economy in operations depends upon the particular application of the Autoleveller, and examples can be given of seven operations reduced to three, with two operators instead of six, and of eight reduced to four, with six workers in place of ten. Economies in floor space also result; in the first example quoted 1,600 sq. ft. are required instead of 2,600, and in the second example 3,600 sq. ft. suffice in place of the 4,800 required when traditional methods are used. The wastage figures also show a marked improvement.

Before yarn can be spun it has to pass through several preparatory processes, one of which is drawing. This process involves drawing out the fibres into a continuous untwisted strand or sliver. Natural variations in the material cause variations in the thickness, and therefore in the weight per unit of length of the sliver. This variation must be removed if the finished yarn is to be uniform, and it has been done in the past by the process known as doubling, that is, repeating the drawing several times in order to even out the variation.

The Raper Autoleveller, which has been designed by Mr. G. F. Raper, and is now in full-scale production by Prince-Smith and Stells, Limited, Keighley, Yorkshire, detects the variation in sliver weight and applies the necessary correction in the drawing mechanism automatically.

SELF-CONTAINED MEASURING AND CONTROLLING UNIT

The Autoleveller is a self-contained unit which is attached to the feed end of the drawing machine. It measures the thickness of the sliver being processed and then, after a delay which is necessary to allow the point on the sliver which has been measured to reach the drawing rollers, applies a correction by varying the speed of the rollers. The thickness measurement is transmitted to a mechanism which stores the result temporarily in the form of a wave pattern or graph. A further mechanism then uses this pattern as the basis for the transmission of suitable drawing-speed adjustments. The pattern is automatically formed, stored, used and then cancelled, in order to allow the mechanism to be used continuously. The Autoleveller is entirely mechanical in operation. It can be applied in various ways, and to different types of machine, but its basic principle is unaltered however it is used, and its application to a Gill or draw-box is typical.

The Gill-box, Fig. 1, is a multi-head machine and each head is fed by a single sliver through a funnel and then through drawing rollers and fibre control units, which perform the actual drawing operation. When the Autoleveller is applied to a Gill-box it is located behind the back rollers. The front rollers rotate at a constant speed delivering a constant length of material, while the back rollers and fallers on the ingoing side of the machine are speed-controlled by the Autoleveller. The variation of faller and back roller speed increases or reduces the draft to level out the uneven places.

The Autoleveller has three main component assemblies: a measurer and setter, a transmitter, and a speed control. The measurement of sliver thickness is made by a pair of rollers, between which the sliver runs. One of these rollers is on a fixed bearing, the other "floats" on a bearing on the end of a lever, and is spring-loaded to rest on the sliver. Variations in sliver thickness cause the floating roller to ride up and down, and so to move the lever through a greater or lesser angle. The lever is of the first order, with a longer arm on the side away from the roller, so the movements of the latter are magnified.

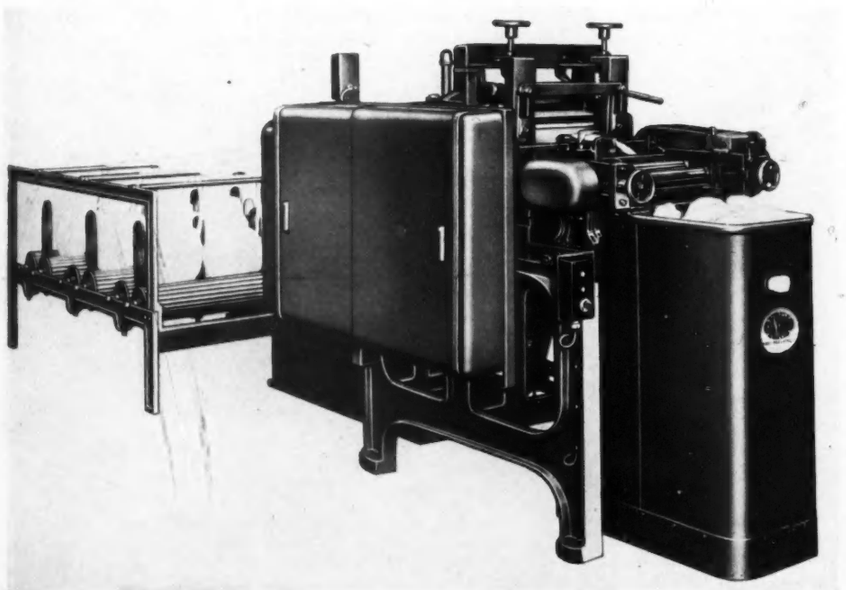


Fig. 1 A Gill-box, for processing textile sliver, as seen from the delivery end. With the "Autoleveller" fitted, the rate of drawing is controlled to produce yarn of constant thickness.

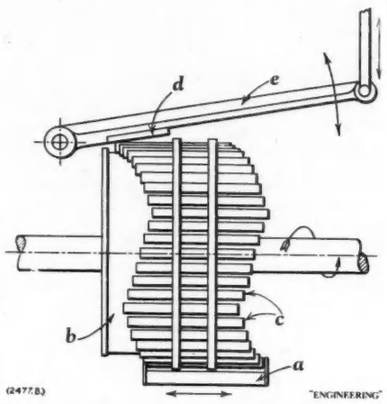


Fig. 2 Diagram of the Raper Autoleveller, showing how variations in sliver thickness are recorded mechanically and used to control the rate of drawing.

The lever is connected to a yoke (*a* in the diagram, Fig. 2), which straddles and overhangs a wheel *b*, which carries on its periphery a number of rods *c*, mounted axially and free to move in that direction, but restrained radially. Movement of the floating roller causes the yoke *a* to move, and it pushes the rods to one side or the other as the wheel is rotated past it. As they leave the point where the yoke straddles the wheel, therefore, the rods are left projecting more or less from each side of the wheel according to the movements of the roller, lever and yoke. The rods thus take up a wave-like profile, which is a graphical representation of the thickness profile of the sliver, though it is, of course, different in wavelength and amplitude, because of the magnifying effect of the lever, and the relative speeds of the wheel periphery and the sliver.

MECHANICAL INTERPRETATION OF WAVE PATTERN

As the wheel continues to rotate, it brings the wavelike profile of the rod-ends into contact with the transmitter, which feels the extent of projection of each rod and transmits it, with any required degree of magnification, to the variable-speed gear. The transmitter consists of a series of contact pads *d*, which are so mounted that they can move in a plane at right angles to the axis of the wheel *b* carrying the rods *c*, and can make contact with the rods themselves. The contact pads are connected to the variable-speed gear by a simple arrangement of levers *e*. Since the plane of movement of the contact pads is at right angles to the axis of the rod-wheel, and the inclination of the contacting surfaces is small, there is no tendency for the rods to slide axially, and the degree of projection of each rod is measured by a greater or lesser movement of the contact pads.

This movement is transmitted by the levers *e* to a fork controlling a belt running on a pair of cones with their bases opposed. One of the cones is driven at a constant speed; the other is driven by the connecting belt at a speed which varies according to the position of the belt. Thus, if the belt is near to the base of the driving cone, it will be near to the apex of the driven one, and the latter will rotate at its highest speed, and vice versa. The drive to the drawing rollers is taken from the driven, or variable-speed cone.

The extent of projection of the rods having been measured, it is necessary to re-set them so that they are once more equally disposed on the width of the wheel, and so ready for the setter

to form a fresh wave-line as the wheel rotates. This is done by causing the rods to pass between two fixed contact plates which are, in effect, opposed inclined planes. The rod-ends make contact with these plates and are pushed back to lie symmetrically on the periphery of the wheel, ready to pass between the arms of the setter yoke once more. The delay between detection of sliver thickness variation and the required speed adjustment, which is necessary to allow the point on the sliver which has been measured to reach the drawing rollers, is determined by the proportioning of the Autoleveller mechanism, and by the radial disposition of the setting and transmitting units around the rod-wheel.

The weight variation which can be detected and dealt with by the Autoleveller depends upon the type of machine and operation to which it is applied; when used with a draw-box it is ± 25 per cent. A continuous indication of weight variation is given by a pointer working over a graduated scale, and if the weight limit is exceeded an electrical detector stops the machine and lights a warning lamp.

* * *

ELECTRONIC FLOWMETER FOR AIRCRAFT FUEL

Fuel Reserves Indicated Within ± 1 Per Cent.

To satisfy the need for an accurate indication of the rate of fuel consumption of an aircraft and the fuel reserve available at any given moment, a new type of electronic flowmeter is now being manufactured, under licence from Établissements Faure-Herman, Boulogne-Billencourt, France, by Integral Limited, Birmingham-road, Wolverhampton.

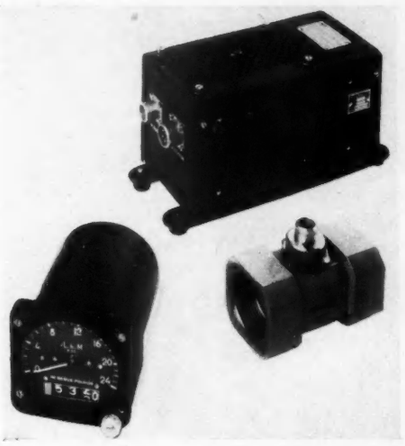
The electronic flowmeter is compact and exceptionally light in weight, and over the greater part of the calibrated range gives an accuracy of fuel-reserve indication to within ± 1 per cent. The present range of instruments are calibrated in pounds and are intended for fuel of specific gravity 0·78 (aviation kerosene), but meters calibrated in gallons can be supplied on request. A 115-volt 400-cycle supply and a 24-volt (nominal) direct current are required for operation of the instrument.

As may be seen in the accompanying illustration, the instrument comprises three units—a generator (bottom right), which measures flow by the free rotation of a helical rotor; an electronic relay which receives signals from the generator and computes from them independent indications of the reserve fuel and the rate of flow; and an indicator which presents these readings separately. For twin-engined aircraft, or other cases where there are two fuel-supply lines, the signals from two generators can be added together in a single electronic relay and presented on one indicator.

One of the blades of the helical rotor, which is freely pivoted within a cylindrical casing, carries a small magnet which induces a small pulsation in an inductor coil mounted in the generator casing. The restriction to flow caused by the generator unit is about 1·5 lb. per square inch at a flow of 15,600 lb. per hour; under stopped-rotor conditions the pressure drop will rise to about 3·5 lb. per square inch.

The inside diameter of the generator casing is selected to give a whole-number relationship between the number of rotor revolutions—and thus the number of pulses in the inductor coil—and the quantity of fluid passing, expressed in the desired units. At present five sizes of generator are available, for flow ranges from 0-35 lb. per minute to 0-600 lb. per minute. The pulses are amplified by the electronic relay and after suitable conversion are fed to the rate-meter and counter-meter circuits.

In the counter circuit, the number of pulses received is divided by the appropriate whole



Fuel oil passing through the generator causes a small magnet on the blade of the rotor to induce in a coil a current which is relayed to the fuel gauge as a rate of consumption. Five models cover flow ranges from 0 to 35 lb. and 0 to 600 lb. per minute.

number so that for every unit of fuel passing through the generator one pulse is passed to the counter of the reserve-fuel indicator. In the rate-meter circuit, however, a direct-current voltage is generated proportional to the frequency of the received pulses, and is fed to the rate-of-flow section of the indicator. Thus indications of both rate and total fuel consumption are functions of frequency only and are independent of voltage variations due to varying rotor speed.

The indicator housing contains two separate instruments—a milliameter sensitive to the output of the rate-meter circuit, and a solenoid-operated counter recording the fuel reserve available, or, alternatively, it can be supplied to record the total fuel consumption.

* * *

HORIZONTAL CRACKS IN CONCRETE FLOOR SLABS

Assessing Cracking Below Granolithic Surfaces

The presence of horizontal cracks in concrete floor slabs—either at the reinforcement or on bedding planes—can be detected by simply sounding the top of the floor with a suitable bar. By this method and despite its simplicity the presence and extent of cleavage may be determined with a fair degree of accuracy. When a new floor has been placed, particularly those with a granolithic topping, investigation as above will in all probability show the existence of some horizontal cleavage; in general this may not of itself be harmful and the floor may have a prospective life as good as can reasonably be expected from such floors. Nevertheless, before the floor is "taken over" from the contractors it is desirable to be able to determine whether the floor is likely to be sound or if the cracks are of such a nature that the unsatisfactory sections of the floor should be cut out and replaced because of faulty work.

The significance of the crack depends on three factors: its extent, the width of the opening and its depth below the surface. If the crack is very fine and at a considerable depth it is unlikely that the crack will extend due to the "working" action of passing loads; on the other hand a relatively thick crack at a shallow depth will grow under the action of surface loads and ultimately the top surface will spall and will have to be made good. The extent of the crack may be determined as already mentioned by sounding, but fairly exhaustive inquiry some time ago failed to disclose a simple method of determining the other two factors of crack width and depth. For this reason the apparatus shown in the accompanying illustration and described below was devised by the research department of W. S. Atkins and Partners, consulting engineers, Whitehead House, Vauxhall Bridge-road, London, S.W.1. Though very simple in principle it has been shown to be very easy and quite effective to use.

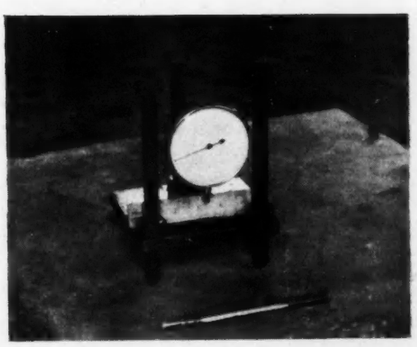
A coach screw is set into the top surfaces of the concrete with its head protruding so that, by putting a lever under the head, a lifting force can be applied to the slab. A suitable location for the screw is readily chosen from a consideration of the extent of the crack and of the type of measurements that are going to be made.

The instrument consists of an elementary tripod mounting carrying a sensitive dial gauge the plunger of which works against the head of a probe. The probe has an expanding foot or collet which can be opened-up to grip against the wall of a hole drilled into the concrete slab. If the probe is locked into the concrete below the crack then any movement applied to the top of the slab will be indicated on the dial gauge; if, however, the probe is locked above the crack then the probe moves with the top of the slab, there is no relative movement between the probe and the tripod, and no reading is to be observed on the dial gauge. Plotting the movement for a number of depths of the probe gives a close indication of the depth of any crack. Examination of the data obtained in this fashion, and taking into consideration the strength of the concrete, provides sufficient information to deduce whether or not the crack is likely to spread.

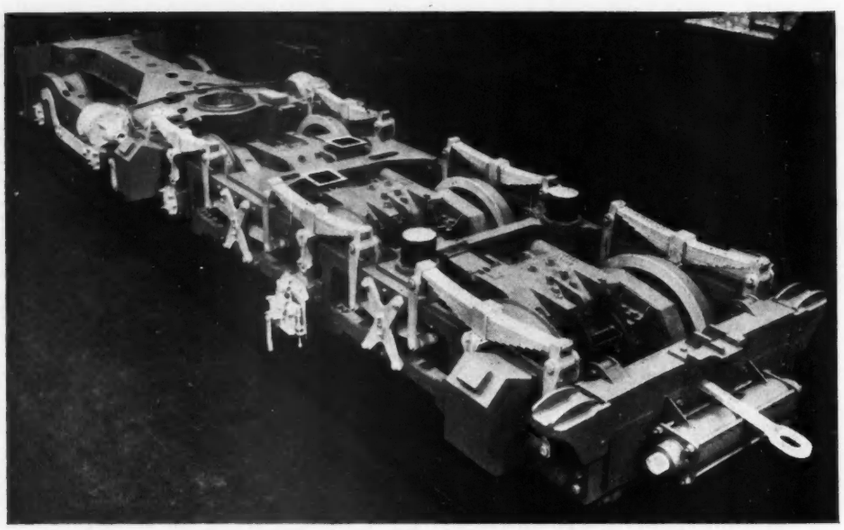
The accuracy of the instrument has been checked by using it on a slab in which cracks had been artificially introduced by leaving paper inserts in the concrete. The results of this experiment are shown in the following Table which shows that the depth can be determined to within about $\frac{3}{8}$ in., an accuracy which tallies with that aimed at in the design, the length of the collet being $\frac{3}{4}$ in.; it is quite possible that a shorter collet would still have an adequate gripping length and be more accurate.

Actual depth (in.)	$1\frac{1}{4}$	$1\frac{1}{2}$	$1\frac{3}{4}$	$1\frac{7}{8}$	$1\frac{7}{8}$	$2\frac{3}{8}$	2
Measured depth (in.)	$1\frac{1}{2}$	$1\frac{7}{8}$	$1\frac{3}{4}$	2	$1\frac{5}{8}$	$2\frac{7}{8}$	$3\frac{1}{8}$
Error (in.) ..	0	$\frac{3}{8}$	$\frac{1}{8}$	$\frac{1}{8}$	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{8}$

It was found that the instrument would detect relative movements of ·0001 in. between the head of the probe and the surface of the slab. From the same experiments, using floors with artificial cracks of known extent, it was found that the sounding test was accurate to within about $\frac{3}{4}$ in. for determining the boundaries of the crack.



The extent of horizontal cracks below granolithic surfaces to concrete floors can be determined by sounding. The depth of the crack and its thickness can be found by setting a probe with an expanding foot into the concrete slab at varying depths about the crack and recording the relative surface movements when the slab is loaded.



The six-wheeled three-motor motor bogie with its two-wheeled pilot bogie.

1,500-H.P. DIESEL-ELECTRIC LOCOMOTIVES FOR NEW ZEALAND

COMPACT DESIGN NECESSITATED BY TRACK CONDITIONS

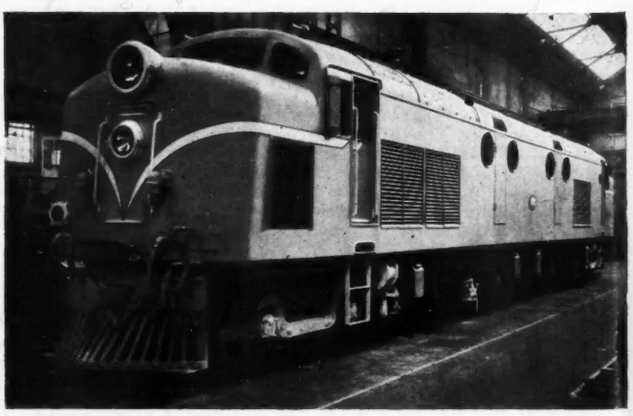
A number of difficult problems had to be solved in designing the ten 1,500-h.p. Diesel-electric locomotives which have recently been constructed at the Preston works of the English Electric Company, Limited, for passenger and freight service on the 425-mile 3 ft. 6 in. line between Wellington and Auckland in the North Island of New Zealand. In the first place the locomotives are required to operate within a severely restricted loading gauge, while the axle loading was limited to 12 tons to secure maximum route availability. To comply with the latter stipulation a 2-Co-Co-2 wheel arrangement was adopted, the locomotive being carried on two three-axle main motor bogies, each of which incorporates a two-axle pilot bogie. The tractive forces are transmitted through king pins and the drawgear is mounted on the transoms of the main bogies. A spring-controlled guiding connection is provided between the bogies to assist in maintaining correct relative alignment and to minimise flange wear. The extensive use of light alloy for the unstressed parts has enabled the total weight to be kept down to 105 tons.

As the central portion of the line includes a 21-mile section with an average gradient of 1 in 60 and a 14-mile section with a gradient of 1 in 50 without compensation for curvature, much of which is of 7½ chains radius, the locomotives are equipped with dynamic electric braking. It is hoped that this will materially assist in reducing the wear on the air brake equipment, especially when descending long gradients.

MECHANICAL CONSTRUCTION

The locomotive superstructure is fabricated as a stress-bearing unit. The main members of the underframe are concentrated between the bogie pivots and distribute the tractive and buffing forces which are applied through the main bogies. The main longitudinal members of the underframe comprise two outer girders of channel section and two inner fabricated girders of rectangular hollow section. The underframe assembly is jig-welded and was cambered and pre-loaded before the superstructure side trusses were attached. These trusses are of triangular section and were fabricated from rolled steel and flanged sections. The side and fixed roof panels of the body are attached to the superstructure framing by arc welding. The roof over the engine generator unit, air compressor, electrical control frames and the resistance frames for dynamic braking is removable. The underside of the superstructure is sealed off from the bogies to prevent oil from reaching the traction motors and running gear.

The load from the locomotive superstructure is transferred to the main bogies (one of which is shown above) through pivot bearings and helical spring bearers. The bogie side frames are supported by laminated springs with compensating beams between each pair of driving wheels. The frames of the pilot bogies are of monobloc cast-steel construction and are fitted with drop-type equalising beams. The load from the main to the pilot bogies is carried on a centre bearing and is transmitted to the pilot bogie frame by a cast-steel bolster and side-control rocker mechanism. The centre pivots of both the main and pilot bogies have phosphor-bronze liners on the bearing surfaces. The axleboxes, which are of cast steel, are fitted with roller bearings. The axlebox guides are provided with manganese-steel liners on the faces and on such cheeks as are subject to side thrusts.



One of the 1,500-h.p. Diesel-electric main line locomotives for the New Zealand Government Railways.

DIESEL-ELECTRIC EQUIPMENT

The Diesel engine, main generator and auxiliary generator form one unit which is supported on resilient mountings. The engine, which has an output of 1,500 h.p. at 850 r.p.m., is fitted with two Napier turbo-chargers, each of which serves six of the 12 cylinders. The governor, which is driven by a camshaft at the flywheel end of the engine, regulates the quantity of fuel delivered by the fuel pumps by means of a servo mechanism which is operated from the lubricating oil system. The engine is started by motoring the main generator from a 48-cell lead-acid battery. The protective features include devices which automatically shut down the engine in the event of its speed rising above a predetermined maximum; of the lubricating oil pressure falling below a predetermined minimum; and of low cooling-water level.

The main generator is provided with separately excited and self-excited field windings together with a further field winding which is used when it is motored from the battery to start the engine. It supplies current to six nose-suspended, series-wound, forced-ventilated traction motors which are connected in three parallel groups of two in series. The auxiliary generator, which is a shunt-wound constant-voltage machine, is overhung from the main generator and supplies current for the control circuits, the excitation of the separately excited field of the main generator, and battery charging, as well as the blower motors and locomotive lighting.

AIR SUPPLY ARRANGEMENTS

Air for the main and auxiliary generators is drawn into the generator compartment through louvres and filters in the sides of the locomotive by two motor-driven fans, and is expelled into the engine compartment from which it is exhausted through the roof ventilators. The Diesel engine draws in air through louvres and filters mounted high in the sides of the body and transmits it independently to the air intake of each turbo-charger. Air for the radiator is drawn through louvres in the sides of the locomotive and, after passing across the cooling elements, is expelled vertically by the mechanically-driven radiator fan. Cooling air for the traction motors is drawn through louvres and filters in the sides of the nose compartments by the blowers and is conveyed to the traction motors through ducting and flexible bellows. Cooling air for the dynamic braking resistances is drawn in through louvres

in the sides of the body and is forced through the resistance banks by motor-driven blowers, after which it is expelled through the roof.

ELECTRIC CONTROL EQUIPMENT

The master controller in the single cab incorporates a main control handle, reverser, and master switch. The control handle is used to regulate the output of the engine-generator unit according to power requirements. It has ten notches which correspond to progressively increased generator power outputs, these being obtained by the use of engine speeds of 450, 620 and 850 r.p.m. in conjunction with varying degrees of main generator field excitation. The master switch controls the starting and stopping of the Diesel engine.

When the control handle is in the tenth notch, automatic torque regulation is brought into action. This adjusts the excitation of the main generator so that its output corresponds to the available engine horse-power, irrespective of the locomotive speed. Field weakening of the traction motors is automatically obtained when the device previously mentioned has reached its position of maximum travel, which corresponds to the maximum field strength of the traction generator.

During dynamic braking the traction motors generate current which is absorbed by resistances, their fields being disconnected from their respective armatures and reconnected in series with the main generator. The traction motor fields are excited during dynamic braking from the main traction generator the degree being controlled through the excitation of the main generator field. An increase in the excitation of the main generator field causes a higher current to flow through the traction motor fields and consequently to increase the dynamic braking effort.

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INVITATION TO VISIT STEEL RESEARCH LABORATORIES

The work of the London group laboratories of the British Iron and Steel Research Association will be open for inspection by all interested persons at 140 Battersea Park-road, London, S.W.11, on Thursday and Friday, November 18 and 19, between the hours of 10 a.m. and 5 p.m. Visitors will be able to inspect the facilities provided for conducting research into many aspects of the iron and steel industry's problems, and displays of current and recent research projects, illustrated in many instances by test rigs and working or static models, will be on view.

TUBULAR BUILDING STRUCTURES

Standard Components Facilitate Rapid Erection

A demonstration was recently given at the Barkingside works of B. Finch and Company, Limited, to show how quickly the skeleton of a 33-ft. 4-in. span building 60 ft. long, in four bays of 15 ft. by 12 ft. high to the eaves, can be erected. The superficial area was 2,000 sq. ft. and the cubic content calculated half-way up the rise of the truss was 31,000 cub. ft. The material was brought to the site in one lorry and was erected by three men in 3½ hours. The illustration shows the final stages of erection.

The structure is designed so that, depending on the purpose, the wall infilling can be asbestos sheeting, either to ground or dwarf-wall level, brickwork or concrete blocks, these two types of wall incorporating the steel columns as piers. Roof lighting by means of patent glazing, dead-lights or Perspex sheets can be incorporated with an asbestos-clad roof and side lighting of various types can be fitted. Buildings of this nature and size are suited to a variety of purposes and a number have been erected for use as garages, showrooms, office buildings, warehouses, airport buildings and small hangars.

The structural section used is steel tube, which is particularly suitable for members in compression, apart from its ability to withstand other loads. Furthermore, it is claimed, buildings constructed from round tubular section generally use about 50 per cent. less steel because of the greater strength of the section.

Fast erection of the building is possible because it is built from a number of standard frames and components, which are factory produced. Each individual frame is welded together on jigs to ensure interchangeability. A combination of welded and bolted parts facilitate handling and final erection. Only two diameters of screw thread are used, ⅝ in. and 1 in. Two tools, a double-ended spanner of the sizes mentioned and a pipe wrench for holding the longitudinal tubular members which have studs in each end, are necessary.

Standard frames are at present being produced for buildings from a 15-ft. lean-to to a 40-ft. span truss, and from an 8-ft. to 16-ft. column in 2-ft. stages. The module of length used in this range is 15 ft. but to meet special requirements a bay of 12 ft. 6 in. long has also been introduced. "Valley" columns are made to allow variations in the design of buildings. They enable roofs to be erected in valley formation. Special valley supporting columns are available with a cap plate which seats two truss shoes. Each component as well as the complete structure is designed and calculated to accord with B.S. 449-1948.

During the demonstration it was stated that one set of standard components, such as those used on the demonstration structure, weighs about 3 tons, which is one lorry load by weight.

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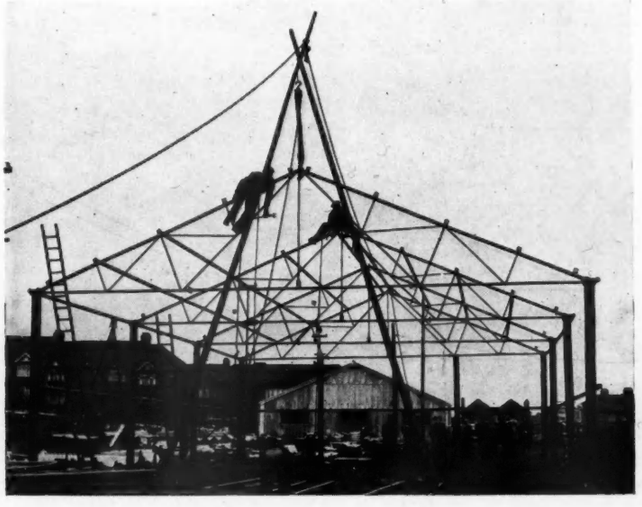
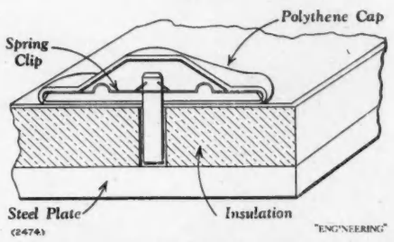


This tubular structure, which took 3½ hours to erect, is built from standard sections of welded tubular steel. Only two sizes of screw thread are used.



A simple method of fixing thermal or acoustic insulation to plates, employing stud-welding and spring clips.

FIXING INSULATION ON METALLIC SURFACES

The Admiralty has for some time now been using a Fibreglass sheeting known as Navyboard for deck and bulkhead insulation on warships. This particular use of a Fibreglass material, and the stud welding procedure adopted for securing the sheeting, may be of interest to builders of commercial ships and, possibly, to manufacturers concerned with other fields of engineering where it is necessary to attach thermal or acoustical insulation to metallic surfaces, including aluminium.

The Fibreglass sheeting employed for warships varies in thickness between ¾ in. and 2 in., and is semi-rigid, faced on one side with a specially-treated puncture-resisting glass-cloth. Various methods of fixing the material were considered, including drilling and bolting or riveting, but the method eventually accepted was that developed by the stud welding organisation of Crompton Parkinson, Limited, Crompton House, Aldwych, London, W.C.2, in co-operation with the manufacturers of the insulation, Fibreglass Limited.

After cleaning and marking out the surfaces to be covered, ⅛ in. diameter plain pins, having flat but slightly chamfered outer ends, are stud-welded to the platework. The insulation is then impaled on the pins and finally secured by polythene-capped "Speed Fixes," the latter consisting of perforated spring-steel clips or washers having two teeth which, with light finger pressure, can be pressed over the pins which they then grip tightly. The arrangement of the fastening can be seen in the accompanying illustration.

In addition to the advantages of simplicity, speed and low cost there is no perforation made in the metal structure; thus the formation of weak spots susceptible to corrosion and mechanical stresses is precluded. Protection against corrosion is still further provided by covering the ends of the pins with polythene caps.

The pins for stud-welding may be of either steel or aluminium alloy, according to the nature of the metallic surface to be covered, and the structure should be at least 1/16-in. thick if it is of steel, and ⅛-in. thick if it is of aluminium or aluminium alloy.

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CABLE CONTRACTS

Model Form of General Conditions

A new model form of General Conditions of Contract—known as "E—Home Cable Contracts with Installation"—has been published by the Institution of Electrical Engineers, and copies can be obtained from the Secretary, Savoy-place, Victoria-embankment, London, W.C.2, at the price of 5*s*., post free. The new form has been designed specifically for use in cable contracts which include installations.

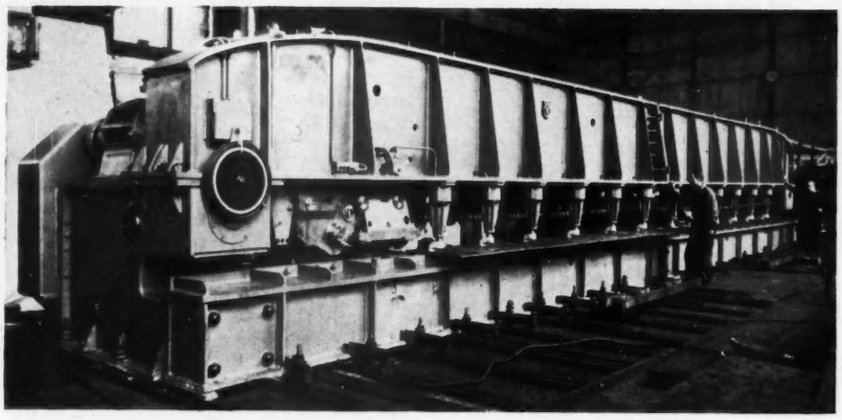


Fig. 28 Shears for cutting and squaring long plates, in which a cutting disc is moved along by a carriage.

THE EUROPEAN MACHINE TOOL EXHIBITION AT MILAN

5—SOME MISCELLANEOUS EXHIBITS

Concluded from page 575

Mere limitations of space prevent the description of more than a selection of the machines in an Exhibition that contained the products of more than 840 firms from practically the whole of Western Europe. In this, the concluding article of our series, therefore, we can include only a few of the very many exhibits not otherwise touched upon, but will endeavour to take them from among the machines manufactured in countries to which no previous reference has been made.

ROLLER SHEARS

An imposing Austrian exhibit was that of the Vereinigte Österreichische Eisen- und Stahlwerke, of Linz-Donau, who showed, among other heavy tools, a roller shears for cutting and squaring long plates (Fig. 28). This machine is constructed in two forms, the BR type having an upper beam and the BL type being without this beam. The illustration shows the former type. The frame is fabricated from steel plate and fully annealed after welding. The plate to be cut is held down against the straight lower blade, which consists of a number of equal elements bolted into position, by pneumatic clamps. The upper blade is in the form of a disc supported on a travelling carriage. The upward reaction to the cutting pressure is taken by rollers which press against the upper beam, and sideways movement of the circular cutting blade is prevented by brackets and shoes bearing against a guide beam. It is stated that the deviation from a straight line does not exceed ± 1 mm. As a rule, two circular blades are mounted on the carriage, one revolving in the vertical plane and the other being set at an angle of either 30 deg., for bevelling the edges of plates that are to be welded, or 18 deg. for seams that are to be caulked. Either blade can be engaged or disengaged independently of the other by means of a handwheel. The range of capacities of the four sizes in which the BR machine is made covers plates from 8 mm. ($\frac{5}{16}$ in.) to 30 mm. $1\frac{3}{16}$ in.) in thickness and of lengths from 6 m. (19 ft. $8\frac{1}{4}$ in.) to 15 m. (49 ft. $2\frac{1}{2}$ in.). The smallest machine, which is driven by a motor of 14 h.p., cuts at a speed of $15\frac{3}{4}$ in. per second and the largest, which has an 80-h.p. motor, at $7\frac{7}{8}$ in. per second. The carriage is drawn along the the straight lower blade by an endless flat-link chain, the driving and reverse sprockets being contained in the end supports. The reverse sprocket is adjustable to regulate the tension of the chain. Control of cutting is by push-button switches; the plate clamps are controlled by a hand lever.

SLIDE-WAY GRINDER

Another machine exhibited by the same firm was a wet grinder for the slide-ways of planing machines, etc. (Fig. 29). It consists of a bed-plate resting on a baseplate, on which it is aligned by means of wedges, and carrying a travelling table which slides on the bedplate guides. The corresponding slides on the table have plastic inserts to reduce friction. On machines having a table travel of 10 to 20 ft., the traversing motion is hydraulic, the cylinder being mounted in the frame of the table, which serves as a reservoir for the hydraulic fluid, and the piston rod being attached to the bedplate. In machines with a longer travel, the table is driven by a worm gear and pinions. On the table is mounted a column supporting an outrigger in the form of a cast hollow girder which can be raised and lowered, or, if desired, arranged to swivel; and on the outrigger are two grinding heads which can be swivelled independently about their vertical and horizontal axes, so that any form of longitudinal or transverse guide can be ground with the use of additional attachments. A wheel-dressing head is provided on each of the grinding heads and is brought into use by hydraulic remote control. A pump carried on the table draws water from a channel in the bed and delivers it to the point of grinding, the used water being led by other channels to a filter before being recirculated. Although primarily designed as a wet grinder, the machine can be used also for dry grinding, for which purpose a dust-collecting system is provided. The dust extracted is separated in a cyclone filter which discharges it into the wet-grinding water circuit, where it is collected in the filter in that circuit. The smallest size in which the machine is made has a table travel of 9 ft. 10 in., and the largest, 39 ft. 4 in. All the sliding surfaces, including that of the vertical column carrying the outrigger, are protected by leather bellows against damage by swarf.

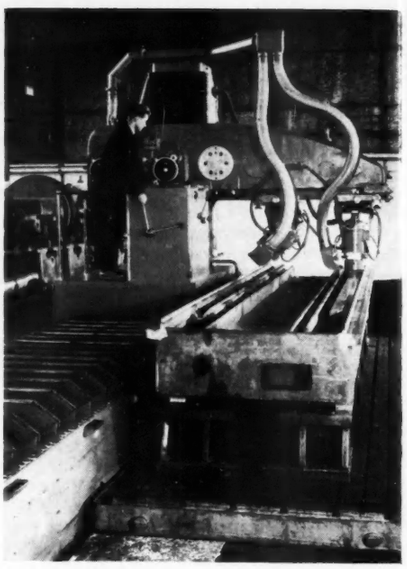


Fig. 29 Machine for grinding slide-ways, with two grinding heads on an outrigger arm.

DYNAMIC BALANCING MACHINE

From the wide range of testing machines, balancing machines, and associated apparatus exhibited by the well-known German firm, the Losenhausenwerk Düsseldorfer Maschinenbau

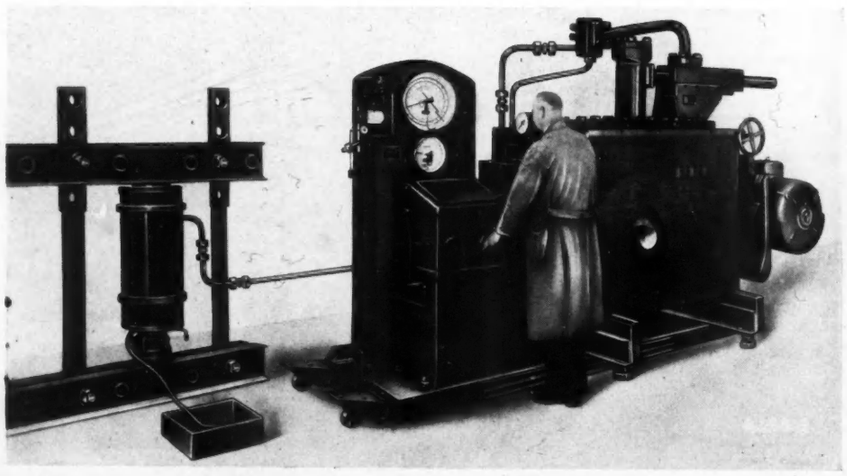


Fig. 30 " Individual testing cylinder " shown mounted in a frame which is to be tested. The cylinder is connected to a control desk and oil pump. A pulsator can be added if required.

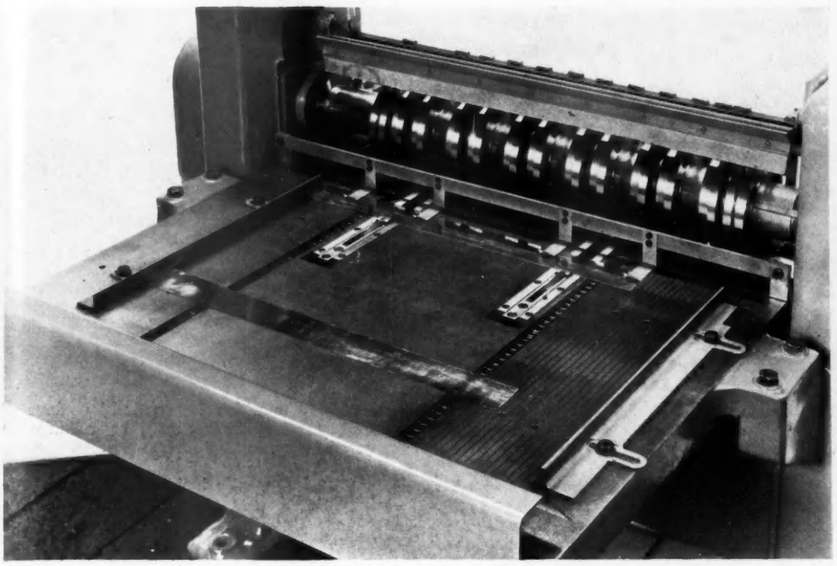


Fig. 31 Gang slitting machine for cutting a number of strips simultaneously.

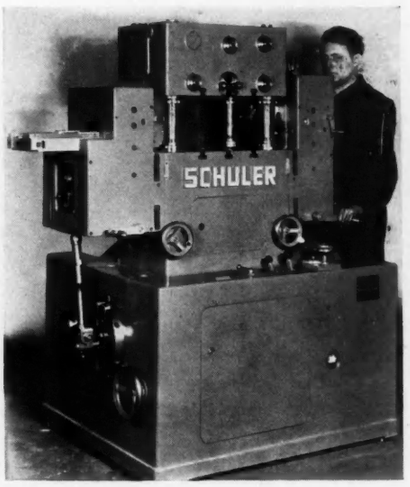


Fig. 32 A high-speed press which is under-driven from a crankshaft in the base of the machine.

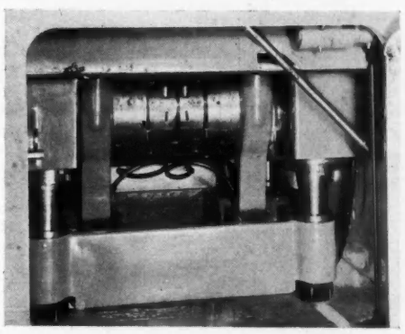


Fig. 33 Spring device used on the high-speed press to avoid slack due to clearance in the bearings. Tool life is thereby improved.

A.G., of Düsseldorf-Grafenberg, Germany, we have selected for mention one of their dynamic balancing machines and a portable hydraulic cylinder for applying loads to large and cumbersome structures such as girders, etc., which cannot be conveniently taken to a fixed testing machine. The principle of all the "UA" range of balancing machines is to apply the compensation mechanically and to indicate the out-of-balance electrically. In the case of small components, the specimen under test is supported rigidly in the machine, in a manner similar to its actual operating condition, and the out-of-balance is indicated by a piezo-electrical method. For the larger types of component, this high-speed procedure is not applicable for practical reasons, and accordingly they are run at low speeds in the resonance range. Either type of machine is capable of measuring a displacement of the centre of gravity of 0·005 mm. to 0·001 mm. or even less in some cases. The shape of the specimen does not affect the operation, and the necessary readings can be made in a few seconds of actual running.

TESTING CYLINDER

The individual testing cylinder illustrated in Fig. 30 is intended to be mounted in the framework to be tested and connected by pressure pipes to a control desk, which contains the oil pump and gauges. The cylinder is provided with pressure plates and a spherical bearing at each end. A pulsator can be readily inserted in the system if desired. Springs return the piston to its starting position when the pressure is released, even if the cylinder has been mounted in an inverted position. The stock sizes have lapped pistons with a stroke of 250 mm. and are designed for maximum static loads of 4, 10, 20, 40, 60 and 100 tons.

Fig. 34 High-duty hobbing machine for worm-gear pinions.

GANG SLITTING MACHINE

L. Schuler A.G. of Göppingen, Württemberg, were another German firm who showed a wide variety of machines. Among them was the gang slitting shear illustrated in Fig. 31, which cuts a number of strips simultaneously from sheet metal by means of rotary cutters. The cutter shafts are ground and are supported in wide bearings, with ball bearings for axial location. The cutters are normally screwed on to clamping rings which slide along grooves in the shafts, but, if their setting is not likely to be disturbed for long periods, or if very narrow strips are to be cut, spacing bushes are used. The strips as cut are free from burrs, parallel and flat, provided that suitable material is being employed. The sheets are placed on the table and are moved forward by means of a pedal-operated stop. The smaller models are intended mainly for the toy trade and for similar work in which tinplate is used. The largest size is employed principally in the electrical industry, for cutting blanks for transformer and motor laminations, etc. The cutters can be dismantled without removing the shafts from the machine, and can be sharpened *in situ* by the use of an electrically-driven grinding attachment. To adjust the cutters after grinding, a height adjustment is provided; this does not affect the drive, as an intermediate gear is provided in the gearing connecting the upper and lower shafts.

HIGH-SPEED PRESS

A high-speed press, under-driven from a crankshaft in the base of the machine, was also shown by L. Schuler A.G. The position of the crankshaft is indicated in Fig. 32 by the slotted plate at the end of the shaft, which drives the feed mechanism. The ram is guided in the frame and is actuated by a pitman at each end of the crankshaft; this double drive ensures that the face of the ram is always parallel with the table. To reduce any slack due to the clearance in the bearings, springs are fitted (Fig. 33) so that the punch begins to cut immediately it comes into contact with the strip stock and its penetration into the die is no more than the minimum necessary to effect a clean cut. It is claimed that these arrangements for taking up the bearing clearance and avoiding any tilting of the ram have a

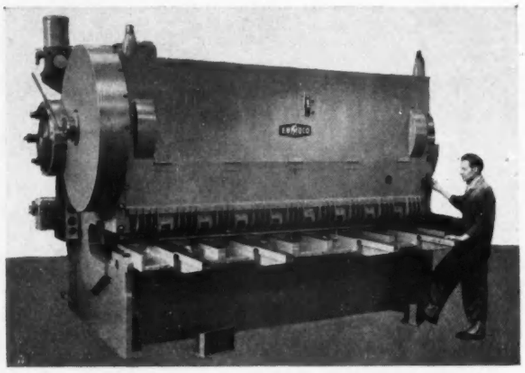


Fig. 35 The upper blade of the Eumeco guillotine shear can be swivelled in order to cut plates at any desired angle, particularly for subsequent caulking or welding.

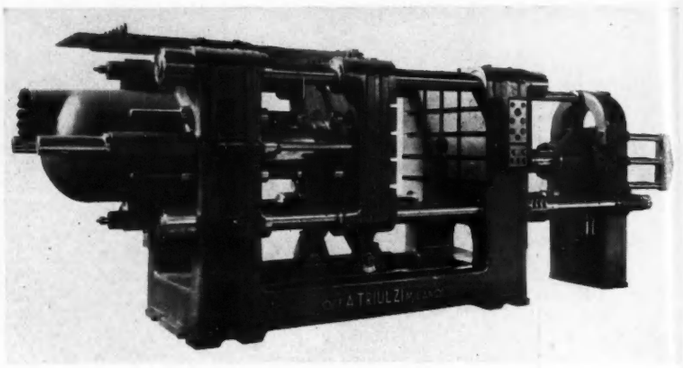


Fig. 36 A cold-chamber die-casting machine which has a locking force of 1,200 tons. It is suitable for producing large aluminium and alloy castings for the motor industry.

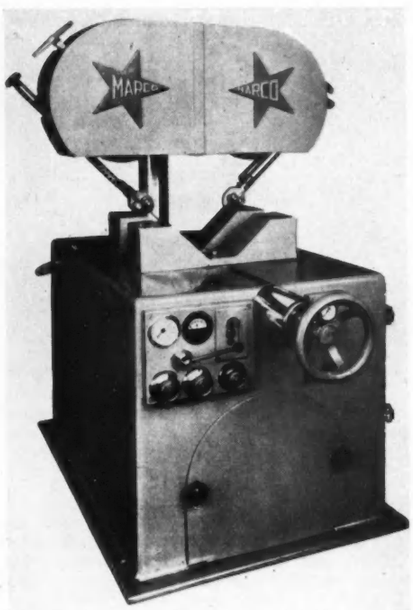


Fig. 37 A bandsaw for making two mitre cuts simultaneously at 45 deg.

markedly beneficial effect on the life of the tools. Wear is also minimised by fitting a trimming shear which cuts off the two ends of the strip so that its length is an exact multiple of the feed; thus no incomplete stampings are produced and there is no consequent tendency to deflect the punch and cause it to strike the edge of the die. A scrap shear is also provided at the back of the machine, to cut the pierced strip into any desired length for baling. This shear can be put out of action when tool-setting is in progress, so that the setter can judge from the pierced strip whether the press is functioning correctly. The rate of stamping may be as high as 500 strokes per minute, corresponding to an output of 60,000 to 100,000 blanks per working day. The upper portion of the press frame can be inclined backward about the axis of the crankshaft so that components which cannot fall through the bolster may slide out to the back of the machine.

HOBBING MACHINE

The Hermann Pfauter Wälzfräsmaschinenfabrik, of Ludwigsburg, Württemberg, Germany, displayed a representative selection of their gear-cutting and hobbing machines, including two, the P 160 and P 500, of entirely new design. The P 160 is a high-duty hobbing machine (Fig. 34) for worm-gear pinions, which has been developed from the earlier RS 10 type and will deal with pinions up to 160 mm. in diameter and 4·5 module pitch, and of lengths up to 355 mm. over the work. The motor, which has a speed of 1,500 r.p.m., drives through a P.I.V. gear and a train of change wheels, giving a stepless speed variation of the hob between 70 and 320 r.p.m., and the distance between the centres of the work and the hob can be varied between 30 and 138 mm. An incidental feature of the machine is the neat stowage provided for the change wheels within the frame of the machine. At the other end of the frame is a withdrawable hopper to collect the swarf.

The P 500 hobbing machine is for larger work up to a diameter of 500 mm. and 8 module pitch, and an axial length over the pinion teeth of 400 mm. The speed of the hob is variable between 45 and 900 r.p.m., and, with a hob 160 mm. in diameter, the maximum cutting speed is 450 metres per minute.

GUILLOTINE SHEAR

The Eumeco Aktiengesellschaft für Maschinenbau, Leverkusen 1, Germany, showed a new type of guillotine shear (illustrated in Fig. 35, at the top of this page) designed to cut not only normal rectangular seams, but also caulking and welding seams at any angle up to 30 deg. or 35 deg. The plate and the tool-holders remain in their normal position, but the upper blade is swivelled round the cutting edge of the lower blade to cut the desired angle by means of an electric motor, with push-button control from the operator's desk, where a scale shows the cutting angle. The blade-holder is adjusted as required through a back gear by an eccentric shaft. The frame of the machine is fabricated by welding. The blades have four cutting edges, and the lower blade is arranged for vertical and horizontal adjustment. The plate to be cut is placed in position either with the aid of a stop which can be adjusted from the control position by means of an electric motor, or it can be set by observing the shear-line indicator. The single-disc clutch is incorporated in the flywheel and is operated by an electro-pneumatic control mechanism. The clamping devices are dis-

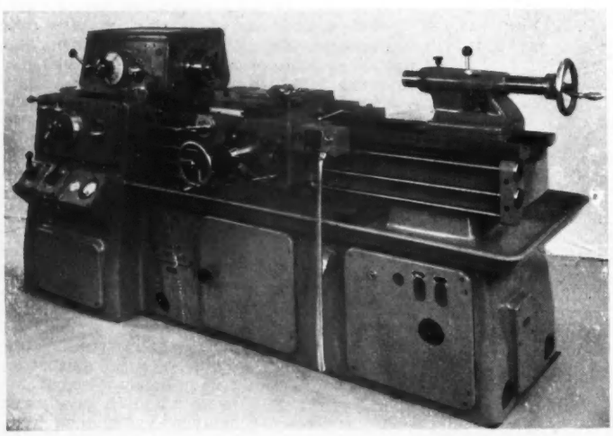


Fig. 38 General-purpose lathe designed to make full use of the capacity of tungsten-carbide tools.

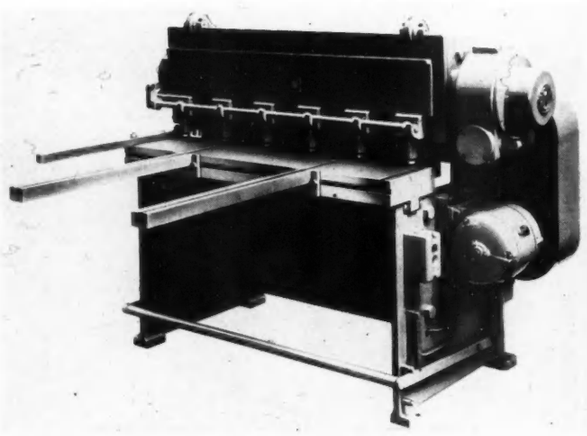


Fig. 39 Precision guillotine shear which can cut to within 0·005 in. Particularly useful for cutting sheet into strips for press tools, etc.

engaged automatically when the machine reaches the end of its stroke.

HIGH-SPEED FORGING HAMMER

Another machine exhibited by the same firm was a high-speed forging hammer with a direct electric drive, which can strike 50 to 55 full-power blows per minute or lighter blows from a lesser height at the rate of 80 to 100 per minute. The drive from the motor is through a V-belt to a flywheel and thence through a simple back-gear to an eccentric shaft. This shaft carries an eccentric disc and is coupled to the drive through a single-disc friction clutch. The clutch control also actuates a disc brake on the eccentric shaft, by which the tup can be stopped in any position. The tup is connected to the eccentric shaft through a flat-link chain. The clutch and the brake are operated by compressed air, through an electro-pneumatic control mechanism, actuated by a foot switch, which may be placed in any convenient position.

DIE-CASTING MACHINE

Of the many Italian exhibits—with the exception of Germany, Italy was represented on more stands than any other nation—one of the most striking was the Model 30M cold-chamber die-casting machine (Fig. 36) shown by Ambrogio Triulzi s.r.l., Via Giovanni da Procida 6-8, Milan. This machine is the largest of a range of six models and has a locking force of 1,200 tons. The pressure medium is water, the main cylinder being prefilled by a centrifugal pump contained within the frame and the final squeeze being given by a pressure-intensifier which supplies extra fluid to the die-closing cylinder immediately prior to injection, to prevent the dies from being forced apart. An interlock prevents injection from taking place unless this extra locking pressure is applied. A safety device by-passes the working fluid to the reserve tank if the machine is operated without the dies in position or with dies of insufficient thickness. The main members of the machine, and also the platens, are steel castings. Guides are provided on the baseplate, on which the moving platen is supported on wheels when heavy dies are fitted, these wheels being eccentrically mounted to permit any vertical adjustment that may be necessary. The end plates of the frame are held together by four tie-bars, 8 in. in diameter. The space between them is 3 ft. 7 in. by 4 ft. 11 in., and the maximum platen opening is 5 ft. 5 in. The main ram has a stroke of 3 ft. 3 in. The working pressure in the hydraulic system is 2,130 lb. per square inch and is applied by a horizontal ram pump, fitted with an air-loaded accumulator, having a capacity of 220 gallons. The operating cycle is initiated by press-button control, but thereafter is automatic through the sequence of injection, opening and ejection of the finished component, a timer regulating the sequence and duration of the movements. The machine is mainly used for producing large aluminium and alloy castings for the motor industry.

GENERAL-PURPOSE LATHE

On the stand of the N.V. Nederlandsche Machinefabriek " Artillerie-Inrichtingen," Hembrug-Zaandam, Holland, there was shown a new model of general-purpose lathe, the Dr 200 (Fig. 38). It is made in two forms which are broadly similar in general outline, but differ in the range of speeds obtainable and in the method of deriving the feed motion; the Dr 200 U has 42 spindle speeds ranging from 23 to 3,150 r.p.m. and is fitted with a lead screw, whereas the Dr 200 P has only half the number of speeds, from 180 to 3,150 r.p.m. and has no lead screw, the feed being imparted by a continuous-current motor with a steplessly-variable speed control. In both, the height of the centres above the slides is 200 mm. and the distance between centres is 1,000 mm. The built-in main motor is of 14 h.p. and drives through a wholly-enclosed gearbox to a Cam-Lock spindle, running in preloaded bearings which are entirely free from backlash. Lubrication is by oil mist. The Dr 200 U machine has a pre-selector for the spindle speeds by which nine speeds can be pre-selected from the control position. The bed and the headstock form a single casting, the consequent rigidity enabling tungsten-carbide tools to be used to their fullest capacity while maintaining the highest precision and surface finish.

MITRE-CUTTING BANDSAW

A new type of mitre-cutting bandsaw was included among the exhibits of the Marco Machinefabriek en Handelsonderneming, 8, Nieuwstraat, Spijkenisse, Holland. The machine, type 35, is intended for shipyard use and for cutting the frames of steel windows, structural sections, etc. The accompanying illustration (Fig. 37) will indicate the general principle of the design and the manner in which two cuts are made at once, at an angle of exactly 45 deg. It will take work with a cross-section overall of 350 mm. by 250 mm. (13¾ in. by 9¾ in.), with no restriction on the shape of the section to be cut, within those overall dimensions. There is a three-speed drive to the saw, which is fed hydraulically through the cut. The same pump which provides the pressure of the feed also operates the vice. It is fitted with a strainer type of filter and also with a magnetic filter. Roller supports can be fitted if required to support the uncut bar and also the portion which is being removed.

PRECISION GUILLOTINE SHEAR

Another Dutch firm who exhibited were Messrs. Laagland, Piekstraat 2, Rotterdam, whose D.M.F. precision guillotine shear is illustrated in Fig. 39. This machine has been designed to cut steel sheet into strips with high accuracy—it is claimed that an accuracy within 0·005 in. is easily maintained—for use in press tools, etc. The maximum cutting width is 1,100 mm. (43 in.) and the clear distance between the housings is 1,150 mm., giving a clear inch on each side for handling the sheet into position for shearing. The maximum sheet thickness is 4 mm. ($\frac{5}{32}$ in.) and the rate of cutting is 100 strokes per minute. The knives fitted are four-edged. The drive is by V-belt from a 3-h.p. motor to an intermediate shaft, running in bal. bearings and having on it a pinion that is integral with the shaft. This pinion meshes with the main gearwheel, which serves also as the body of a clutch, actuated by a pedal. The pedal actually operates a shaft on which there are two trip dogs. When the pedal is partly depressed, only one trip comes into action; this engages the clutch and causes the machine to make one stroke. The second trip disengages the clutch. A limit stop is fitted to restrict the movement of the pedal for single-stroke cutting; when this is removed, the pedal can be completely depressed and the clutch remains engaged until the pedal is released. There are six spring-loaded clamps for holding down the sheet, and a back gauge with two large micrometer dials is provided, which can be set at an angle if desired.

An associated Laagland company, the Wotan Gereedschapswerktuigenfabriek, Piekstraat 20, Rotterdam, showed a number of shaping machines including the Wotan 16, which has a stroke of 15¾ in. maximum and 1¼ in. minimum, and a speed range from 24 to 152 strokes per minute. The work table measures 15⅜ in. by 11 in. and can be traversed either by power or by hand. It has a horizontal travel of 17¾ in. and a vertical movement of 13¾ in. The driving motor is of 3½ h.p. The machine can be started and stopped instantly by a single lever, which operates the friction clutch and also a brake. Automatic pressure lubrication is provided to all working parts inside the column. This machine is one of a number on different stands which are stated to be designed in accordance with the principles and working tolerances laid down by the late Dr. George Schlesinger in his book on *Testing Machine Tools*.

A LAST LOOK AT THE EXHIBITION

It has been impracticable to mention more than a few of the many interesting designs of machine tools exhibited at Milan. The range of tools displayed by the machine-tool section of the famous Fiat firm, at Modena, for example, occupies the greater part of a 56-page catalogue and covered such diverse machines as vertical and radial drilling machines, gang drills, gear cutters and shapers, bevel-gear generators, large electrical and hydraulic multiple boring mills for internal-combustion engine cylinder blocks, and horizontal multiple drills for sewing-machine bodies.

In the section of the Exhibition devoted to small precision machines and measuring instruments the Apparecchi Elettronici Marposs, Via Artieri 2, Bologna, showed electronic comparators for cylindrical grinding machines, capable of reading to within ± 0·00002 in. on either internal or external work, and guaranteed to maintain this accuracy even though the voltage should change as much as ± 15 per cent.

AUTOMATIC TURRET LATHE

A new type of automatic turret lathe, which is made in five sizes, was exhibited by the Manufacture de Machines du Haut-Rhin, Mulhouse-Bourtzwiller, Haut-Rhin. It is a single-spindle machine fitted with five transverse tool-holder slides and a turret carrying six tools. There is a separate stop for the length of the workpiece, so that all six turret positions can be utilised for cutting tools. The non-cutting motions, such as tool-withdrawal, gear-changing, indexing, etc., are accelerated to reduce operating times. The drive from the motor (6 h.p. or 8 h.p., according to size) is transmitted to the spindle by silent chains through a gearbox in the bed, and friction couplings engage or disengage the four automatic spindle speeds, two clockwise and two anti-clockwise, used for drilling, boring, screwing and tapping. The main camshaft is driven through worm gearing and actuates the transverse tools, the turret and the longitudinal motion. An auxiliary camshaft carries clutches for advancing and gripping the bar stock, reversing the rotation of the spindle, changing the spindle speed and indexing the turret. The smallest size of this type of lathe, the TR 12/16, will take bars up to 18 mm. in diameter, with a maximum length of work of 75 mm., and the largest, the TR 52/60, 60-mm. bar and a 100-mm. workpiece.

Machines for removing burrs from gear teeth were shown by the Sheffield Corporation, Dayton, 1, Ohio, U.S.A. The 380 Series, as this range is termed, will de-burr or chamfer from 200 to 600 teeth per minute, according to the model used, and can be employed on cluster gears, planetary gears and splines as well as on the more ordinary type of gearwheel.

VERTICAL BORING MILL

The French firm of Berthiez (Société Anonyme des Anciens Etablissements Charles Berthiez) of 5 Rue Montalivet, Paris 8e, whose works are at Givors (Rhône) and Fives-Lille (Nord), showed two new machines, the Type 9130 vertical boring and turning mill, and a combined planing and milling machine. The boring mill is of the single-column type, with two tool-holders mounted on the arm, and has a revolving table 2,400 mm. (7 ft. 10 in.) in diameter. This table, however, can slide along a bed parallel to the arm carrying the toolholders, so that the maximum diameter which can be machined is 3,800 mm. (12 ft. 6 in.). The table and bed are designed to take work up to 50 tons in weight. The table speeds are infinitely variable, the main driving motor having Ward-Leonard control. The machine is made in five sizes, the largest taking work up to 12,000 mm. in diameter.

The planing and milling machine shown at Milan has a width between the uprights of 2,000 mm. (6 ft. 7 in.) and a stroke of 6,000 mm. (19 ft. 9 in.) and will plane or mill, as desired, with each of its two tool-holders. Moreover, the inside face of the tool-holder carriage has a circular T-slot which allows either a universal milling head, a right-angle head or a high-speed head to be fitted. The machine can be used for boring also when fitted with the makers' Type FA 1 tool-holder.

Fig. 19 The Ford "Vedette," a French car designed in Detroit. It has a body of typically American size and employs a unit body-chassis structure.

Fig. 20 Transparent roofs of tinted plastic are now in production for the American Ford and the Mercury shown here.

The Motor Show, London (*October* 20 *to* 30) (*concluded from page* 578)

TRENDS IN THE DESIGN OF MOTOR CARS

3—BODIES, TRANSMISSIONS AND BRAKES

No European designer now seems to contemplate production of small cars in large numbers with separate chassis. All new models intended for large-scale production have unit structures although the larger cars still have chassis. The Lanchester Sprite is a unit structure but the Daimler Conquest and Regency made by the same group have chassis. Noise in unit structures still presents a tiresome problem. Rubber insulation of the cross-member carrying the front suspension is used on the small Standards, the Borgward 1500, and others. There is widespread use of rubber in suspension joints, and Metalastik have a spring abutment with conical rubber insert to isolate coil springs from the rest of the structure. They also make a wide range of rubber universal joints for transmission shafts, Laycock also make joints with rubber inserts for the same purpose but rubber joints are little used in British car transmissions, although fairly widely employed on the Continent.

UNIT STRUCTURES

Although the unit structure has not made much headway on the larger cars built in the United States, the big groups there are gaining unrivalled practical experience with the design problems. General Motors designers have collaborated on the Vauxhall, Opel and Holden while the Ford engineers were intimately concerned with the Fords built at Dagenham and Cologne and with the new Ford Vedette (Fig. 19) which will be built at Poissy in France. The latter is particularly interesting as it is a relatively large car designed to afford body space to American standards within compact overall dimensions more suitable for Europe. Interior dimensions are within a few centimetres of those on the American Fords and the luggage locker gives about 50 per cent. more space than that current in French practice. The V8 engine, developed from that on the previous Vedette, gives 80 b.h.p. but the car weighs over 700 lb. less than the American equivalent.

It has a stiff box-section chassis integral with the floor, with the side members built out to meet the body sills and rocker panels where they form a stiff triple box section under the door openings. By attaching reinforcements to the inner wing valances a strong subsidiary structure has been created to support engine and suspension. The complete structure is stronger both as a beam and in torsion than the combined body and chassis of the American Ford, as the figures in the next column show.

—	Vedette 8 Unit structure	U.S.A. Ford V8 Body and chassis
Vertical deflection under load of 1 ton	1·2 mm.	1·7 mm.
Torsional deflection, lb.-in. per degree	87,300	58,460

Five separate sound-proofing materials have been used on this car, glass fibre, felt, asphalted paper, rubber and resin rubber. Other sound-damping methods now in use include fitting sound-absorbing blocks inside structural members and, of course, the bitumen spray on the inside of the body panels. The bitumen or rubber undercoating now being offered as a treatment for cars already in use has, of course, important sound-damping qualities but in all these treatments the added weight may cancel out much of the benefit obtained from the ingenuity of the designer.

There still seems to be little practical interest in steps to protect the passengers from injury in the event of an accident. Control knobs and switches still project from wood or metal facia panels. In a few cases rubber-filled pads are used on the top of the instrument panel. These have been seen on several American cars and the Jensen 541 is a good British example. This car also has a crash pad above the windscreen and the passenger's grab handle is well recessed. There is no sign in Britain yet of a collapsible steering column which would protect the driver's chest in the event of impact, or even of a steering wheel with recessed boss and V-shaped spokes such as have appeared on the Kaiser and various experimental models in the United States. Lap straps are now fitted on various foreign sports cars and might well reduce the possibilities of injury on fast touring cars.

ALL-ROUND VISION

Adoption of all-round vision on British cars seems to be progressing more slowly than in some other countries. It appears that British safety-glass manufacturers are still reluctant on optical grounds to contemplate the sharp curvatures now found in production in America and some Continental countries. Much attention has been attracted by the wrap-round windscreen introduced by Cadillac, Oldsmobile and Buick (Fig. 21). Structurally these demand a heavily cranked door pillar just at the point of maximum stress and therefore seem more suitable for cars with separate chassis than for unit structures. The main area of the screen is still a long way from the driver's eyes so that interference can still be created by dirt or rain drops on the surface and it does not seem possible for the windscreen wipers to work effectively round the corners.

Fig. 21 "Wrap-round" windscreen for improved vision.

Ford and Mercury (Fig. 20) have taken the very bold step of going into large-scale production with coupé bodies having tinted transparent tops of plastic material, although the problems of scratching are still far from solved. There is also a transparent sliding roof which can be obscured by an opaque inner shutter, offered as an extra on the French Vedette.

PLASTIC BODIES

Two cars were exhibited with plastic bodies in 1953—a Jowett and a Singer—but neither body went into production. Singer have,

Fig. 22 Finned light-alloy brake drum as used on all current Alfa-Romeo cars.

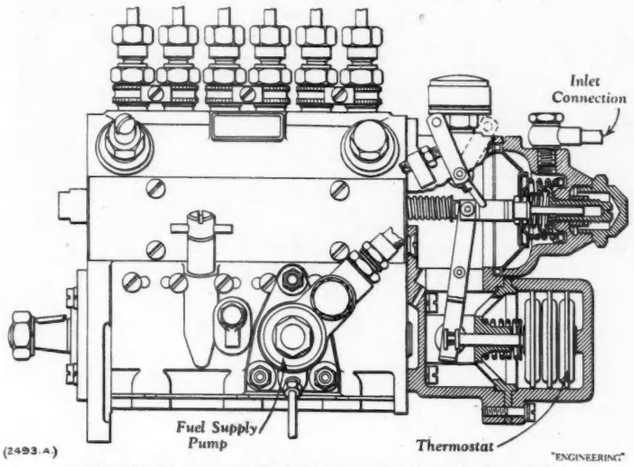


Fig. 23 Bosch petrol-injection pump with control system.

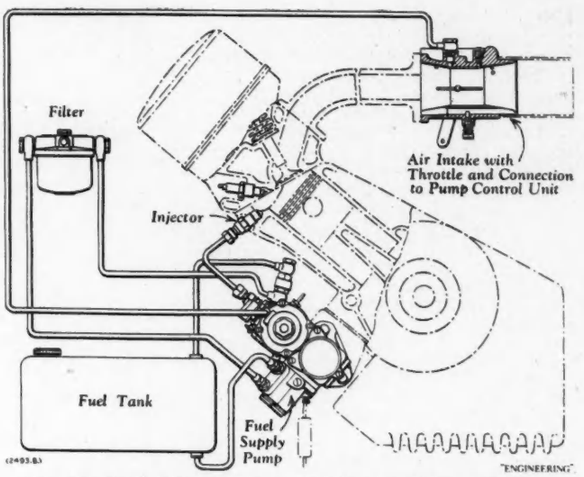


Fig. 24 Bosch injection system on Mercedes Benz sports car.

however, profited by the experience to make plastic bonnets and wing valances reinforced with glass fibre for their latest saloon. Several companies are now engaged in research on the problems of plastic body production. The largest production so far achieved is on the Chevrolet Corvette sports model in the United States, where up to 50 cars a day are said to have been made with the aid of heated moulds, but in Britain cold curing seems to be universal. I.C.I. are interested, through Marstons of Wolverhampton, in making the detachable hard top for the Triumph sports two-seater. Kieft showed a plastic body on their own sports car and are offering it for fitting to other chassis. But this year's most ambitious project is the Jensen 541 plastic coupé, which will shortly be put into production by a company which has already been making plastic boot lids and wings for its other models.

Meanwhile, light alloys make slow but steady progress, the Lanchester Sprite being the latest car to use aluminium for unstressed parts such as bonnet, wings, doors and boot lid.

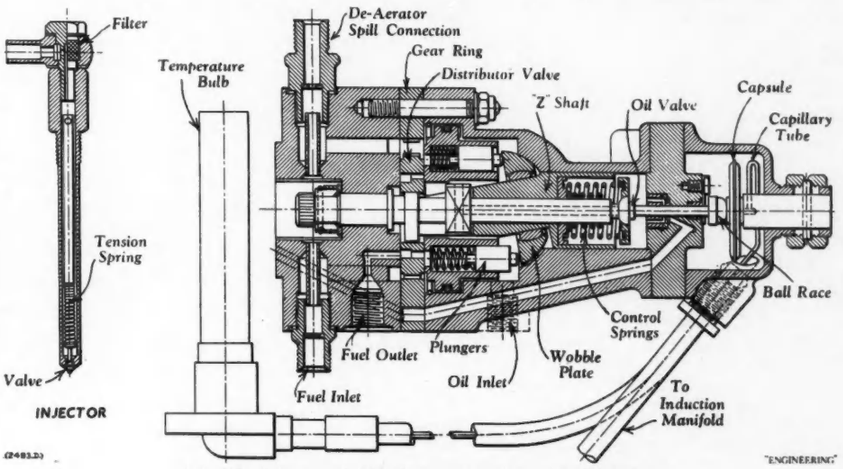


Fig. 25 S.U. petrol-injection pump and associated injector.

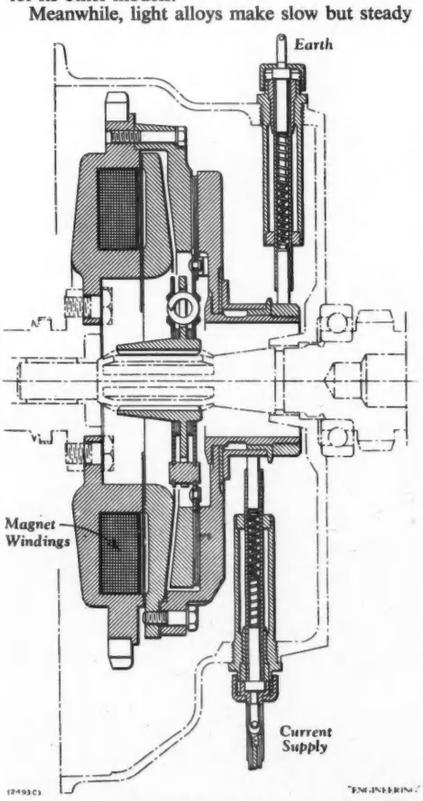


Fig. 26 Cross-section of the Ferlec magnetic clutch.

FUEL INJECTION

Two systems of fuel injection exhibited at the Motor Show indicate the future trend away from carburetters for high-performance engines. The British S.U. pump, developed from one already used on armoured fighting vehicles, is in use experimentally on several racing cars, while the Bosch system is offered in production on the Mercedes 300 SL car. By eliminating imperfections of distribution and mixture ratio, injection allows a higher compression ratio to be used, and to judge by the fuel-consumption figures claimed for the Mercedes, may also show some economies to offset its higher price.

The Bosch system (Figs. 23 and 24) is developed from Diesel injector techniques. The pump is driven from the camshaft at half engine speed and has one plunger per cylinder. As on Diesel engines, control of output is by a rack which rotates the pump barrels and varies the effective stroke of the plungers. Rack movement is controlled by air-manifold depression and also by a capsule sensitive to atmospheric temperature and pressure. There is a throttle valve and Venturi on the air intake and, as the throttle valve moves, air-pressure variations are communicated to a piston controlling the rack. Injection takes place during the inlet stroke at a pressure of 120 atmospheres and the timing is not critical.

The S.U. system (Fig. 25) injects into the inlet ports as near to the valve as possible, whereas the Bosch system injects direct into the combustion chamber. The S.U. pump incorporates a speed/density metering system which assumes that air consumption is proportionate to engine speed and air density in the inlet tract. The pump, therefore, has a constant volumetric efficiency with plunger displacements controlled by the density of the incoming charge. The pump is normally driven at engine speed, enabling each plunger to feed two cylinders, but for racing engines turning at over 5,000 r.p.m. the pump is driven from a camshaft at half engine speed and each plunger feeds only one cylinder. The plungers are driven by a wobble-plate mechanism and the amount of wobble-plate movement is controlled by a servo piston subject to pressure of a control spring, which may be opposed by oil pressure from the engine lubrication system. The oil supply is varied by a valve actuated by a capsule responsive to pressure and temperature. The interior of the capsule is connected to a bulb in the induction tract and the outside is subject to manifold pressure. An additional control spring against the servo piston serves to richen the mixture for full power.

TRANSMISSIONS

In the transmission field, the outstanding British developments are the extension in the use of Rolls Royce gearbox, derived from the General Motors Hydramatic, which is now available on Armstrong Siddeley cars, and the introduction of the British Hobbs automatic gearbox on the new Lanchester Sprite. The Hobbs transmission is already in use on buses and is under development for fighting vehicles. It is entirely mechanical and therefore has a

high efficiency. It consists of a compound planetary gear in conjunction with two hydraulically-actuated friction clutches and three hydraulically-loaded brakes which enable four forward speeds to be obtained. The gears can be selected manually by a lever under the steering wheel or they can be changed automatically by means of a governor system which changes the gears up and down at predetermined road speeds. In the latter case, a kick-down valve connected to the accelerator pedal allows higher speeds to be held in each gear for acceleration and hill climbing. Among the advantages of the system are its quiet running when at rest as all the gears are stationary in neutral.

Although British manufacturers now lead Europe in the application of fully automatic transmissions, the French appear to be gaining a lead in the practical application of means to easier driving on small, cheap cars. The 2 CV Citroen now has a centrifugal clutch which frees itself at engine speeds below 1,000 r.p.m., in addition to the conventional plate clutch. The driver thus has no need to use the clutch pedal when starting or stopping.

Some small 4CV Renaults are already being delivered experimentally without a clutch pedal, and will be so offered at extra cost early next year. On these cars, a Ferlec electric clutch, shown in Fig. 26, is used in conjunection with the normal gearbox. The clutch, made by the French Ferodo Company, is a single-plate unit, using sintered-metal linings instead of the conventional friction material. Pressure is maintained by electromagnets instead of springs, the windings being connected to the car's dynamo to ensure a smooth take-up from rest. There is also a rheostat in the circuit, connected to the throttle pedal. Micro-switches built into the base of the gear lever cut the current and free the clutch as soon as the lever is touched, and engage it again when the change is completed.

BRAKES

Brake development is now proceeding on two parallel lines: the development of the disc brake, and the improvement of the drum brake by better cooling and the use of servo devices to reduce the pedal pressure required. Two British cars are now on sale with disc brakes developed by Dunlop: the Jaguar D-type and the Austin-Healey 100 S. On the Jaguar, the brakes have three pads and pistons at each side at the front, and two at the rear, and pedal pressure is supplemented by a hydraulic pump driven from the gearbox. The Austin-Healey has smaller brakes, with one pad on each side of the disc, and no servo mechanism is employed. Lockheed disc brakes are still in the experimental stage, using a pivoted calliper casting. A hydraulic piston moves a shoe at one side, and the housing moves over to grip the disc between this and a fixed shoe on the other side.

On the Continent, brake drums for fast cars are often in light alloy, with radial or helical cooling fins to generate a forced draught, as shown by the illustration of the type of drum now used on all new Alfa-Romeo cars (Fig. 22); while Mercedes use the wheel rim as a shroud for the fan blades. The Mercedes brake drum, developed on the sports cars, is now fitted on the Type 300 saloon. Vacuum servos are increasingly used to reduce the pedal pressure required, the Armstrong Siddeley and Lagonda being recent examples.

On the Aston Martin DB3S sports car the rear brakes were originally mounted inboard, adjacent to the differential, but it was found they tended to raise the temperature of the final drive too much, and they are now on the wheels. A more promising field for inboard brakes is at the front on very fast cars. Both the works Lancia sports team and the Mercedes Grand Prix cars have enormous front brakes mounted on the chassis, and connected to the wheels by universally-jointed shafts. An increase in total weight is accepted, in return for a reduction in unsprung weight, and freedom to use very large brakes which could not be accommodated adjacent to the wheels.

COMBINED DUPLICATING, MILLING, BORING AND DRILLING MACHINE

Three-Dimensional Copying

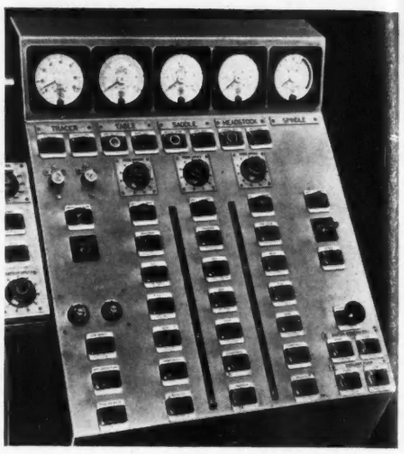
A range of Giddings and Lewis milling machines, with British Thomson-Houston electronic tracer mechanism, is now being marketed in this country by the Rockwell Machine Tool Company, Limited, Edgware-road, London, N.W.2. The machines available are the 4 in. and 5 in. table type and the 6 in. and 7 in. floor and table types. The B.T.H. tracer equipment permits the machining of three-dimensional forms and intricate contours with completely stepless control. The machines can also be used for milling, boring and drilling in the normal manner. They are equipped with high-power motors, the powers being 20, 25, 30 and 40 h.p. for the 4, 5, 6 and 7 in. spindles, respectively. Ample power is also provided for the feed motions, and as the machines are of specially rigid construction, with large bearings, high rates of feed are possible.

STEPLESS TRACING

The B.T.H. tracer mechanism gives simultaneous automatic control of the saddle and headstock or saddle and table for die-milling work, or alternatively, the table and headstock may be controlled automatically for 360-deg. profiling. A single tracing head, which is sensitive to deflection in all three axes, is used for tracing work. Signals from the tracer head are developed in variable-inductance coils which, when they are once set, require no re-adjustment or maintenance. Electronic control gear is provided to regulate the feed motion direct-current motors through Ward-Leonard generators. The feed range has two gear ratios, which are selected by push-buttons. Similar control is provided for the rapid traverse of 120 in. per minute of all three feed motions.

DIE-MILLING AND PROFILING

Die-milling is normally carried out in a series of horizontal or vertical passes, or both. The stepless feed over the surface of the work remains constant irrespective of the steepness of the contours, which may even include undercuts. Adjustable limit switches fitted to the machine automatically reverse the feed at the conclusion of each pass and simultaneously set the next cut. The direction of tracing is shown by one of two light-indicator push-buttons. Operation of the unlit button anticipates the operation of the limit switch. The feed rate in low gear is variable from 0·4 to 5 in. per minute and in high gear it ranges from 4 to 40 in. per minute. The rate of feed in either gear can be varied while cutting. Profiling over 360 deg. of both internal and external forms is entirely automatic, with feed rates as for die milling.



The controls for the machine are grouped on a desk.

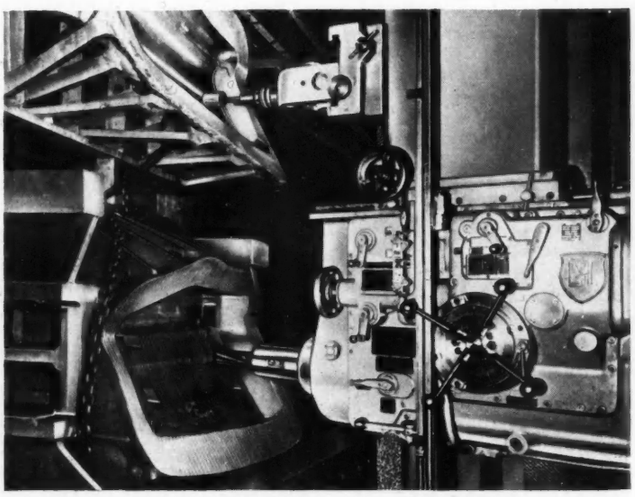
"STEERING" CONTROL

An unusual feature is the "steering" control provided with the tracer mechanism. With this in action a portable rotary device governs the two motions which are to be used under automatic control. The net motion of the stylus relative to the model is then at an angle corresponding accurately with the direction indicated by the arrow on the knob of the control device. The "steering" control can be used to simplify the setting of the tracing head in contact with the model. It is also useful for taking roughing cuts and for facing work on irregular outlines with a facing cutter.

PROTECTIVE EQUIPMENT AND ACCESSORIES

The machine is equipped with protective gear which stops all feed motions in the event of over-deflection or under-deflection of the tracing stylus tip. Over-travel limit switches stop each feed motion in the normal way when using milling feeds, and when steering or tracing are in progress they stop all feeds. Thermal overload protection is provided for all motors, and there is a magnetic overload which stops all feeds if the spindle is overloaded.

The normal equipment of the machines includes hardened bed and saddle ways, spindle-depth gauge and automatic trip. Built-in scales and verniers are provided for accurate boring. There is a wide range of spindle speeds and an infinitely-variable range of milling feeds from 0·2 to 80 in. per minute.



Stepless three-dimensional copying is possible with the British Thomson-Houston tracer mechanism fitted to a Giddings and Lewis milling machine. The machine can also be used for milling, drilling and boring in the usual manner.

Labour Notes

LONDON DOCK STRIKE ENDED

In spite of claims by the leaders of the unofficial strikers belonging to the Transport and General Workers' Union that a "glorious victory" had been achieved, the 44,000 dockers on strike at British ports returned to work last Monday on terms respecting overtime which had been freely offered to them by their employers, and approved by responsible trade-union officials, several months previously.

It may be recalled that the transport employees agreed to take part in the official stoppage declared by the National Amalgamated Stevedores and Dockers and the Watermen, Lightermen, Tugmen and Bargemen's Union, in an endeavour to have all overtime made voluntary.

Immediately following the resumption of work, negotiations were commenced between port employers and union officials in London on practical arrangements for the working of overtime. Discussions between the parties, on much the same terms of reference, were originally suggested as long ago as last January, but did not take place owing to the decision of the N.A.S.D. to impose a ban on overtime in an effort to compel the employers to declare it voluntary.

The strike began on October 4, and lasted for four weeks. It resulted in 44,000 men and some 340 ships at eight British ports being rendered idle. Exports and imports valued at £200 million were held up in docks and factories and the dockers lost about £2 million in wages.

LEADERS TO HOLD MONTHLY INQUIRIES

Among the repercussions of the strike will be its effects on the country's export trade, in which connection the motor industry will be one of the principal sufferers. It was reported on Monday that the Society of Motor Manufacturers and Traders estimated that the industry had lost over 15 million pounds' worth of exports, although it was hoped that much of this loss would be made good later.

Deliveries of goods to sub-Arctic ports may now be difficult or impossible in many cases and Christmas-trade exports to places outside Europe are likely to be jeopardised.

The strike ended as the result of decisions to return to work, taken at a number of mass meetings on Saturday, and carried in most cases by large majorities. Generally, the men seemed to be under the impression that their fight to secure that dock overtime should be voluntary had been won and that, in due course, a national agreement on that basis would eventuate.

An announcement was made by the leaders of the unofficial strikers that meetings of themselves and officials of the N.A.S.D. and the W.L.T.B.U. would be held each month to investigate the progress that had been made in the preparation of agreements at all ports on the principle of making overtime entirely voluntary.

OVERTIME VOLUNTARY BUT NECESSARY

Meetings of the dockers' leaders had been held throughout the whole of last Friday and resulted, after much discussion, in recommendations to the men that they should return to work on Monday. In making their recommendation the men's leaders declared that they did so after taking note of the statement by the Minister of Labour in the House of Commons and of one made that day by Mr. Arthur Deakin, the general secretary of the Transport and General Workers' Union.

Port employers in London had suggested that work should be resumed, with provisions for reasonable overtime, and that there should be negotiations on an agreement for practical arrangements for future overtime.

Sir Walter Monckton later informed the House that there had been a demand that this suggested agreement should be applied to the other ports involved. He said that that demand raised serious constitutional issues. The dispute about overtime had arisen in London and was confined to London. It had led to the official strike by the N.A.S.D. but he was informed that there had been no disputes at other ports about the matter. The strikes elsewhere were in the nature of sympathetic strikes in support of the London stoppage.

Sir Walter said that he understood that satisfactory arrangements for the working of overtime already existed at some of the ports. Accordingly, there was no question of applying to those ports the proposed basis for the resumption of work in London.

In his statement, Mr. Deakin said that his union, while asserting that overtime was voluntary, recognised that it was necessary to the industry. Therefore, any problem respecting its application was a matter for negotiation at the local level and could only be dealt with at the individual ports.

The statement by Mr. Deakin undoubtedly played a major part in bringing about the conclusion of the strike, and was widely referred to at Saturday's mass meetings. It was generally recognised as having been well timed, so as to have the maximum effect.

INCREASE IN TIME LOST BY STRIKES

A considerable increase in the number of working days lost as a result of industrial disputes took place during September last, according to statistics published in the October issue of the *Ministry of Labour Gazette*.

Days lost during September totalled 124,000, compared with only 82,000 in August, and about 107,000 in September, 1953. Allowing for minor colliery disputes, the main cause of the increase in lost time during September last was the strike of ship-repairing employees in London, which began during that month.

That strike, which is still in being, together with the dock strike and the London bus strike, will raise the number of working days lost in industrial disputes to a much higher level for October.

To the end of September last, the number of days lost during the current year, by 275,700 workpeople, was 973,000, compared with a total of 840,000 days lost by 197,900 workpeople during the corresponding nine months of 1953.

SUSPENSION OF STEVEDORES' UNION BY THE T.U.C. GENERAL COUNCIL

The General Council of the Trades Union Congress decided on October 27 that the National Amalgamated Stevedores and Dockers should be suspended from affiliation to the Congress, on account of their alleged action in enrolling into their union members of the Transport and General Workers' Union at Hull, Birkenhead and Liverpool.

This decision was stated to have been taken under rule 13 of the T.U.C. rules and standing orders, which lays down the procedure for taking action against any affiliated body whose activities are considered to be detrimental to the interests of the trade-union movement, or contrary to the declared principles and policy of the Congress.

It is understood that the General Council will deliver a report on the whole matter at next year's meeting of the Congress. That body may then decide whether the union shall be re-admitted, or expelled, or the suspension continued.

The last occasion when a union was suspended from affiliation was in 1928, when the union concerned was the National Union of Seamen. They re-affiliated later.

STRIKE OF STEEL ERECTORS

A small number of men engaged on the erection of steel frames for buildings in the City of London went on strike recently in connection with a dispute over wage rates. The strike spread slightly last week, and brought the number of men idle to 110, employed at over a dozen sites.

An application by their union, the Constructional Engineering Union, for increases of 3½*d.* an hour in London and 2½*d.* in the provinces was declined by the Engineering and Allied Employers' National Federation a short time ago. In support of the claim, the union contends that the men should rank as building craftsmen, and that an agreement signed by the employers in 1947, raised them to that status.

The existing basic wage rate for steel erectors in London is £7 18*s.* 4*d.* for a week of 44 hours. Bonuses and incentive arrangements, together with a certain amount of overtime, mean that earnings amount to around £14 a week in many cases. Wage rates and total earnings are, of course, somewhat lower outside London.

INTERNATIONAL DISCUSSION OF METAL TRADES' PROBLEMS

The regularisation of production in the metals trades, problems of employment at a high level, and practical methods for securing labour-management co-operation in metal-working plants were among the principal items discussed at the fifth session of the metal trades committee of the International Labour Organisation, which opened at Geneva on October 25 and is expected to continue until to-morrow.

The committee's agenda also included consideration of their general report, covering the action taken in various countries in the light of the conclusions adopted at previous sessions of the committee, steps taken by the International Labour Office to follow up the studies and inquiries proposed by the committee, and recent international events and developments in the metal-trades industry.

H.M. Government of the United Kingdom was represented by Mr. C. J. Maston, C.B.E., assistant secretary, Ministry of Labour and National Service, and Mr. D. W. Mitchell, C.B.E., assistant secretary, Ministry of Supply.

Representatives of employers in the United Kingdom were Mr. C. S. Oliver, managing director, Rotherham and Sons, Limited, Coventry, and member of the board of management of the Engineering and Allied Employers' National Federation, and Mr. W. Watson, secretary of the Shipbuilding Employers' Federation. Employees' representatives were Mr. E. J. Hill, general secretary of the United Boilermakers' and Iron and Steel Shipbuilders' Society and a member of the Trades Union Congress General Council, and Mr. W. J. Carron, member of the executive council of the Confederation of Shipbuilding and Engineering Unions and a member of the Trades Union Congress General Council.

Meetings of the committee are held at somewhat irregular intervals; their fourth session having taken place at Geneva in April, 1952.

NOTICES OF MEETINGS

Association of Supervising Electrical Engineers

LONDON
"Cables," by G. E. R. Ledman. Central London Branch. St. Ermin's Hotel, Caxton-street, S.W.1. Mon., Nov. 8, 6.15 p.m.
BIRMINGHAM
Various short papers. Birmingham Branch. Birmingham Chamber of Commerce, 95 New-street, Birmingham. Wed., Nov. 10, 7 p.m.
BRADFORD
"Power Factor Correction," by J. W. L. Fall. Bradford Branch. Midland Hotel, Bradford. Wed., Nov. 10, 7.30 p.m.
YORK
Discussion on "Factory Ventilation." York Branch. Picture House Café, Coney-street, York. Wed., Nov. 10, 7.15 p.m.

British Institution of Radio Engineers

EDINBURGH
"Nuclear Fission and Nuclear Fusion," by Professor N. Feather. Scottish Section. Department of Natural Philosophy, The University, Edinburgh. Thurs., Nov. 11, 7 p.m.
NEWCASTLE-UPON-TYNE
"Stereophonic Sound," by R. A. Bull. North-Eastern Section. Neville Hall, Westgate-road, Newcastle-upon-Tyne. Wed., Nov. 10, 6 p.m.

Chemical Society

ABERDEEN
"Food Legislation During the War," by Sir Harry Jephcott. Aberdeen Branch. Robert Gordon's Technical College, Aberdeen. Wed., Nov. 10, 6 p.m.
MANCHESTER
Various short papers. Manchester Branch. The University, Manchester. Thurs., Nov. 11, 5 p.m.
NEWCASTLE-UPON-TYNE
"The Comparative Organic Chemistry of Nitrogen, Phosphorus and Arsenic," by Dr. F. G. Mann. Newcastle and Durham Branch. Chemistry Building, King's College, Newcastle-upon-Tyne. Fri., Nov. 12, 5.30 p.m.

Combustion Engineering Association

BIRMINGHAM
Discussion "High-Temperature Refractories," at 10.15 a.m.; and "Feedwater Conditioning," by J. F. Hughes, at 2.15 p.m. Midland Section. Imperial Hotel, Birmingham. Fri., Nov. 12.
MANCHESTER
"Sampling for the Small User," by A. C. Dunningham, at 10.15 a.m.; and "Planned Maintenance," by F. W. C. Hinton at 2.15 p.m. North-Western Section. Engineers' Club, Albert-square, Manchester. Wed., Nov. 10.

Illuminating Engineering Society

LONDON
"Shop Lighting," by R. L. C. Tate. Lighting Service Bureau, 2 Savoy-hill, W.C.2. Tues., Nov. 9, 6 p.m.
MANCHESTER
"Street Lighting Costs," by T. L. Robinson. Manchester Centre, Town Hall, Manchester. Thurs., Nov. 11, 6 p.m.

Incorporated Plant Engineers

DUNDEE
"Refrigeration Problems," by G. S. R. Shaw. Dundee Branch. Mathers Hotel, Dundee. Mon., Nov. 8, 7.30 p.m.
MANCHESTER
"Engineering Economics," by T. S. Welch. Manchester Branch. Engineers' Club, Albert-square, Manchester. Tues., Nov. 9, 7.15 p.m.
NEWCASTLE-UPON-TYNE
"Industrial Lubrication," by N. Errington. North-East Branch. Roadway House, Oxford-street, Newcastle-upon-Tyne. Thurs., Nov. 11, 7 p.m.
NOTTINGHAM
"A New Development in Laundry-Washing Machines," by B. A. Clark. East Midlands Branch. Adult Education Centre, Shakespeare-street, Nottingham. Wed., Nov. 10, 7 p.m.

Institute of British Foundrymen

BRADFORD
"Moulding," by L. L. Allard. West Riding of Yorkshire Branch. Technical College, Bradford. Sat., Nov. 13, 6.30 p.m.
LUTON
"Patterns with Special Reference to Pressure-Cast Aluminium Plate," by B. Perry. Bedfordshire and Hertfordshire Section. Town Hall, Luton. Thurs., Nov. 11, 7.30 p.m.
NEWCASTLE-UPON-TYNE
"Dust Problems in Foundries," by W. H. White. Newcastle Branch. Neville Hall, Westgate-road, Newcastle-upon-Tyne. Sat., Nov. 13, 6 p.m.
SLOUGH
"Propeller Manufacture," by J. M. Langham. Slough Section. Offices of High Duty Alloys Ltd., Slough. Tues., Nov. 9, 7.30 p.m.
SOUTHAMPTON
"Solidification of Metals," by A. Prince. Southampton Section. Technical College, St. Mary's-street, Southampton. Thurs., Nov. 11, 7.30 p.m.
STROUD
Discussion on "Foundry Regulations." At works of T. H. and J. Daniels, Ltd., Stroud. Sat., Nov. 13, 3 p.m.

Institute of Fuel

MANCHESTER
"Gas Turbines," by F. Hickson. North-Western Section. Engineers' Club, Albert-square, Manchester. Wed., Nov. 10, 6 p.m.
NEWCASTLE-UPON-TYNE
"Smoke Abatement," by Dr. A. C. Monkhouse. North-Eastern Section. King's College, Newcastle-upon-Tyne. Mon., Nov. 8, 6.30 p.m.
NOTTINGHAM
"Grit and Dust Collection from Industrial Furnaces," by J. O'Breen. East Midland Section. Gas Board's Showrooms, Nottingham. Thurs., Nov. 11, 6.15 p.m.

Institute of Marine Engineers

LONDON
"Doxford Engine," by J. A. Hardy. Student Lecture. Mon., Nov. 8, 6.30 p.m.
"Some Operating Experiences at 950 deg. F.", by L. Baker and W. H. Falconer. Tues., Nov. 9, 5.30 p.m.
PLYMOUTH
"Gas Turbines," by J. Hodge. Junior Lecture. Technical College, Plymouth. Wed., Nov. 10, 7 p.m.

Institute of Metals

GLASGOW
"Metallurgical Problems in Welding Non-Ferrous Metals," by P. T. Houldcroft. Scottish Local Section. Institution of Engineers and Shipbuilders in Scotland, 39 Elmbank-crescent, Glasgow, C.2. Mon., Nov. 8, 6.30 p.m.
SWANSEA
"Some Aspects of Creep," by Dr. J. P. Dennison. South Wales Local Section. University College, Singleton Park, Swansea. Tues., Nov. 9, 6.45 p.m.

Institute of Petroleum

LONDON
"The Chromatographic Analysis of Hydrocarbon Mixtures," by Dr. B. W. Bradford, D. Harvey and D. E. Chalkley. Wed., Nov. 10, 5.30 p.m.

Institute of Road Transport Engineers

BIRMINGHAM
"Hydraulic Servo Systems for Heavy Commercial Vehicles," by J. S. Arton. Midlands Centre. Crown Inn, Broad-street, Birmingham. Tues., Nov. 9, 7.30 p.m.
BRISTOL
"Vehicle Maintenance from the Aspect of Safety," by A. H. Dack and J. H. Vincent. Western Centre. Grand Hotel, Bristol. Wed., Nov. 10, 7.30 p.m.
CARDIFF
"Road Transport Law," by J. Rutter. South Wales Group. South Wales Institute of Engineers, Park-place, Cardiff. Thurs., Nov. 11, 7 p.m.

Institution of British Agricultural Engineers

LONDON
Discussion on "Safety Precautions for Farm Machinery Operatives." Institution of Electrical Engineers, Savoy-place, Victoria-embankment, W.C.2. Tues., Nov. 9, 2.15 p.m.

Institution of Chemical Engineers

LONDON
"Reflections on the Management of Heat," by Sir Alfred Egerton, Eighth Hinchley Memorial Lecture. Geological Society, Burlington House, Piccadilly, W.1. Thurs., Nov. 11, 5.30 p.m.

Institution of Civil Engineers

LONDON
"Some Considerations of Airfield Pavement Design," by J. A. Skinner and F. R. Martin. Airport Division. Tues., Nov. 9, 5.30 p.m.
BIRMINGHAM
"Prestressed Concrete in Practice," by J. Singleton-Green. Midlands Association. James Watt Memorial Institute, Great Charles-street, Birmingham. Thurs., Nov. 11, 6 p.m.
HULL
"Construction of Queen Elizabeth II Dock," by D. C. Milne. Yorkshire Association. Electricity Showroom, Ferensway, Hull. Wed., Nov. 10, 6.15 p.m.
MANCHESTER
Film Evening. North-Western Association. Engineers' Club, Albert-square, Manchester. Thurs., Nov. 11, 6.30 p.m.

Institution of Electrical Engineers

LONDON
Discussion on "Methods of Teaching Technical Writing," opened by G. Parr. Education Discussion Group. Mon., Nov. 8, 6 p.m.
"Standard Frequency Transmissions," by Dr. L. Essen; "The Standard Frequency Monitor at the National Physical Laboratory," by J. McA. Steele; and "Standard Frequency Transmission Equipment at Rugby Radio Station," by H. B. Law. Radio and Measurement Sections Joint Meeting. Wed., Nov. 10, 5.30 p.m.
"Overhaul and Maintenance of Direct-Current Traction Motors," by J. G. Bruce. Thurs., Nov. 11, 5.30 p.m.
LEEDS
Discussion on "New I.E.E. Examination Regulations," opened by Dr. E. C. Walton. North Midland Centre. Yorkshire Electricity Division's Offices. 1 Whitehall-road, Leeds. Tues., Nov. 9, 6.30 p.m.
"Owen Falls, Uganda Hydro-Electric Development," by Sir Charles R. Westlake, T. A. L. Paton and R. W. Mountain. North Midland Centre. The University, University-road, Leeds. Mon., Nov. 8, 7 p.m.
LOUGHBOROUGH
"Properties and Application of High-Permeability Magnetic Alloys," by Dr. G. A. V. Sowter. East Midland Centre. Loughborough College, Loughborough. Tues., Nov. 9, 6.30 p.m.
NEWCASTLE-UPON-TYNE
"Safety in the Use of Portable and Transportable Electrical Equipment in Industry," by J. W. Bunting. North-Eastern Centre. Neville Hall, Westgate-road, Newcastle-upon-Tyne. Mon., Nov. 8, 6.15 p.m.
"The Owen Falls, Uganda Hydro-Electric Development: General Aspects," by Sir Charles R. Westlake, T. A. L. Paton and R. W. Mountain. North-Eastern Centre. King's College, Newcastle-upon-Tyne. Tues., Nov. 9, 6.15 p.m.
SALISBURY
Discussion on "Uses of Electricity in Farming." Southern Centre. Southern Electricity Board's Showrooms, 17 New Canal, Salisbury. Thurs., Nov. 11, 6.30 p.m.

Institution of Mechanical Engineers

LONDON
"Skid-Resisting Properties of Tyres and Road Surfaces," by G. Grime and C. G. Giles; and "Investigations on the Braking Performance of Road Vehicles," by Dr. H. J. H. Starks and R. Lister. Automobile Division. Tues., Nov. 9, 4 p.m.
Discussion on "The British Standard on Drawing-Office Practice." Industrial Administration and Engineering Production Group. Wed., Nov. 10, 6.45 p.m.
"Inspection, Explosion and Breakdown of Boilers and Pressure Vessels," by J. Eyers. Fri., Nov. 12, 5.30 p.m.
MANCHESTER
James Clayton Lecture on "Nuclear Reactors and Power Production," by Sir Christopher Hinton. North-Western Branch. Whitworth Hall, The University, Manchester. Thurs., Nov. 11, 6.45 p.m.
NEWCASTLE-UPON-TYNE
"An Experimental Coal-Burning Gas Turbine," by Professor D. L. Mordell. North-Eastern Branch. Stephenson Building, Claremont-road, Newcastle-upon-Tyne, 2. Mon., Nov. 8, 6 p.m.

Institution of Production Engineers

DONCASTER
"Motion Economy," by Miss A. G. Shaw. Doncaster Section. Danum Hotel, Doncaster. Tues., Nov. 9, 7 p.m.
LEEDS
"Machines and Men," by J. E. Hill. Yorkshire Section. Hotel Metropole, Leeds. Mon., Nov. 8, 7 p.m.
LEICESTER
"Production Milling," by A. R. Hambridge. Leicester Section. Bell Hotel, Leicester. Thurs., Nov. 11, 7 p.m.
PRESTON
"Resistance Welding Fabrication of Small Assemblies," by C. A. Burton. Preston Section. Victoria and Station Hotel, Church-street, Preston. Wed., Nov. 10, 7.15 p.m.

Institution of the Rubber Industry

LONDON
"Nitrile Rubbers," by Dr. E. J. Buckler. Institution of Civil Engineers, Great George-street, S.W.1. Thurs., Nov. 11, 6 p.m.

Institution of Structural Engineers

LONDON
"Precast Ferro-Concrete Constructions in France," by N. Esquillan. Thurs., Nov. 11, 6 p.m.

Institution of Water Engineers

LONDON
"Geology as Applied to Agricultural Land Drainage and Farm Water Supply," by W. H. E. Rivett; and "The Water Engineer and Higher Productivity," by A. J. Chanter. South-Eastern Section. Institution of Civil Engineers, Great George-street, S.W.1. Wed., Nov. 10, 2.30 p.m.

Junior Institution of Engineers

LONDON
"Corrosion," by W. F. Gerrard. Fri., Nov. 12, 7 p.m.
MANCHESTER
"Appearance Design of Engineering Products," by R. M. Kay. North-Western Section. Engineers' Club, Albert-square, Manchester. Mon., Nov. 8, 7.30 p.m.

Manchester Association of Engineers

MANCHESTER
"Early History of Woolwich Arsenal," by Brigadier O. F. G. Hogg. Engineers' Club, Albert-square, Manchester. Fri., Nov. 12, 6.45 p.m.

Manchester Metallurgical Society

MANCHESTER
"X-Rays in Metallurgical Research," by Dr. E. A. Calnan. Central Library, Manchester. Wed., Nov. 10, 6.30 p.m.

Newcomen Society

LONDON
"Far Eastern Engineering," by Dr. H. Chatley. Annual General Meeting. Institution of Civil Engineers, Great George-street, S.W.1. Wed., Nov. 10, 5.30 p.m.

North East Coast Institution of Engineers and Shipbuilders

NEWCASTLE-UPON-TYNE
"Instrumentation in Engineering Research, with Particular Reference to Marine Turbine Machinery," by B. J. Terrell. Neville Hall, Newcastle-upon-Tyne. Fri., Nov. 12, 6.15 p.m.

Royal Aeronautical Society

LONDON
"Boundary Layer Control," by Dr. G. V. Lachmann. Institution of Mechanical Engineers, 1 Birdcage-walk, S.W.1. Thurs., Nov. 11, 6 p.m.

The Royal Society

LONDON
"Optical Properties of Thin Oxide Films on Tantalum," by A. Charlesby and J. J. Polling; and "The Interaction of Oxygen with Clean Metal Surfaces," by M. A. H. Lanyon and B. M. W. Trapnell. Thurs., Nov. 11, 4.30 p.m.

The address and telephone number of the headquarters of each institution are given below. Meetings in the headquarters town are held there unless otherwise stated. Particulars for this column should reach the Editor not later than Monday morning in the week preceding the date of the meeting.

Association of Supervising Electrical Engineers, 23 Bloomsbury-square, London, W.C.1. (LANgham 5927.)
British Institution of Radio Engineers, 9 Bedford-square, London, W.C.1. (MUSeum 1901.)
Chemical Society, Burlington House, Piccadilly, London, W.1. (REGent 0675.)
Combustion Engineering Association, 6 Duke-street, St. James's, London, S.W.1. (WHItehall 5536.)
Illuminating Engineering Society, 32 Victoria-street, London, S.W.1. (ABBey 5215.)
Incorporated Plant Engineers, 48 Drury-lane, Solihull, Birmingham. (Solihull 3021.)
Institute of British Foundrymen, St. John Street Chambers, Deansgate, Manchester, 3. (Blackfriars 6178.)
Institute of Fuel, 18 Devonshire-street, London, W.1. (LANgham 7124.)
Institute of Marine Engineers, 85 The Minories, London, E.C.3. (ROYal 8493.)
Institute of Metals, 4 Grosvenor-gardens, London, S.W.1. (SLOane 6233.)
Institute of Petroleum, Manson House, 26 Portland-place, London, W.1. (LANgham 2250.)
Institute of Road Transport Engineers, 69 Victoria-street, London, S.W.1. (ABBey 6248.)
Institution of British Agricultural Engineers, 24 Portland-place, London, W.1. (LANgham 3394.)
Institution of Chemical Engineers, 56 Victoria-street, London, S.W.1. (VICtoria 6161.)
Institution of Civil Engineers, Great George-street, London, S.W.1. (WHItehall 4577.)
Institution of Electrical Engineers, Savoy-place, Victoria-embankment, London, W.C.2. (TEMple Bar 7676.)
Institution of Mechanical Engineers, 1 Birdcage-walk, St. James's Park, London, S.W.1. (WHItehall 7476.)
Institution of Production Engineers, 10 Chesterfield-street, London, W.1. (GROsvenor 5254.)
Institution of the Rubber Industry, 12 Whitehall, London, S.W.1. (WHItehall 5012.)
Institution of Structural Engineers, 11 Upper Belgrave-street, London, S.W.1. (SLOane 7128.)
Institution of Water Engineers, Parliament Mansions, Abbey Orchard-street, London, S.W.1. (ABBey 6740.)
Junior Institution of Engineers, Pepys House, 14 Rochester-row, London, S.W.1. (VICtoria 0786.)
Manchester Association of Engineers, 20 Booth-street, Manchester, 2. (Central 2796.)
Manchester Metallurgical Society, The Kennedy Press, Ltd., 31 King-street West, Manchester, 3.
Newcomen Society, Science Museum, Exhibition-road, London, S.W.7. (KENsington 1793.)
North East Coast Institution of Engineers and Shipbuilders, Bolbec Hall, Newcastle-upon-Tyne, 1. (Newcastle 20289.)
Royal Aeronautical Society, 4 Hamilton-place, London, W.1. (GROsvenor 3515.)
Royal Society, Burlington House, Piccadilly, London, W.1. (REGent 3335.)